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ECONOMIC IMPACT STUDY OF THE POLLUTION ABATEMENT
EQUIPMENT INDUSTRY

ARTHUR D. LITTLE, INC.

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

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**ECONOMIC IMPACT STUDY
OF THE
POLLUTION ABATEMENT EQUIPMENT INDUSTRY**

Report to the
ENVIRONMENTAL PROTECTION AGENCY

EPA Contract No. 68-01-0553

December 1972

C-74860

Arthur D Little, Inc.

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ABSTRACT

ECONOMIC IMPACT STUDY OF THE POLLUTION ABATEMENT EQUIPMENT INDUSTRY by Arthur D. Little, Inc., (December 1972 — Cambridge, Massachusetts) for the Environmental Protection Agency (Contract No. 68-01-0553)

The objective of this study was to analyze the economic impact of environmental standards on the industries providing pollution abatement equipment to be required by both industry and government. This objective is accomplished through: 1) a characterization of the air and water pollution control equipment industries; 2) an analysis of demand for their products and services; and 3) an evaluation of the impact of that demand upon those industries.

The demand and impact analyses are performed under assumptions of three alternative futures for the 1972-80 period. A *Baseline* (I) scenario extrapolates pollution abatement activity from a base year predating major environmental legislation. A *Federal Compliance Schedule* (II) simulates on-time enforcement of existing standards. An *Expected Compliance Schedule* (III) reflects the contractor's forecast of what may alternatively occur.

The pollution abatement industries analyzed in this study include air pollution control equipment (for particulate and gaseous emissions from stationary sources), water pollution control equipment, instrumentation for air or water pollution abatement, and chemicals for water pollution control. Although these industries suffer from overcapacity and although growth and profitability have not been up to expectations, current profitability is at least equivalent to the returns of companies who might enter these markets from similar businesses. With a return to improved operating rates, there should be no problem in the attraction of investment interest.

The aggregate expenditures needed to control air pollution control from stationary sources are \$12.8 billion. Environmental legislation has already had a major positive impact upon the air pollution control business. The major uncertainty about future demand centers around the availability of proven technology to control sulfur oxide emissions. The analysis of impact, accordingly, is made under two assumptions: a) present technology and practice and b) adequate proven technology in time for 1975-77 application.

Assuming less than adequate technology (a), the on-time enforcement (II) of particulate standards and (where possible) enforcement of gaseous emission controls is projected to unilaterally increase the average costs of equipment over the 1972-80 period by 10.3% for particulate control and 11.9% for gaseous control. Under the expected compliance schedule (III), this cost push inflation is estimated at 2.9% for particulate and 6.7% for gaseous. Under the assumption of adequate technology (b), on-time enforcement (II) would result in a 3.9% inflation of particulate costs and 15.9% for gaseous. Similarly, under the expected compliance schedule (III), the inflation for separate particulate control is 1.7% and that for gaseous control is 13.5%.

The aggregate demand for municipal sewerage expenditures is estimated at \$27 billion. A review of recent municipal construction indicates that actual activity has fallen behind an extrapolated baseline (I) projection from the pre-1965 period. By 1980, however, cumulative expenditures surpass those of the baseline (I) projection in both the on-time (II) and expected (III) compliance schedules. Under the on-time (II) scenario, activity peaks in 1975-76 and then declines to a level associated with new plant construction. Under the expected (III) scenario, municipal plant construction increases steadily until 1980 before it declines to new plant construction levels.

The aggregate demand for industrial water pollution control expenditures is \$9.7 billion. Recent industrial wastewater treatment activity has been substantially above baseline (I) activity. Both on-time (II) and expected (III) compliance schedules are projected to take care of the estimated backlog of needs by the mid-1970's, after which the level of activity will decline to that of new plant construction needs. This indicates that either the cost of industrial wastewater treatment has been underestimated or that industry will soon be in a position to handle another level of standards (e.g., those implicit in the 1972 Amendments to the Federal Water Pollution Control Act).

The anticipated average inflation in water pollution control costs is small under both on-time (II) and expected (III) scenarios. With consideration of the associated water treatment business, the combined water and wastewater treatment equipment business is expected to experience supply-related inflations of 0.8% and 0.3% for scenarios II and III respectively. Water treatment chemicals are forecasted to have an average inflation between 1972 and 1980 of only 0.2% under both alternative futures. Instrumentation for air or water applications is estimated to have an inflation of 4.6% under on-time (II) enforcement and 2.3% under the expected (III) schedule.

Employment in all the industries studied is roughly estimated at 100,000 by 1975 under on-time (II) enforcement schedules. This is about four times as great as 1975 employment (24,000) under the baseline (I) scenario, is about twice as great as that (49,000) under the expected (III) schedule, and may be compared to the more than 200,000 employed in 1967 in the four-digit SIC industries encompassing the pollution abatement equipment industries. At its peak, 1980, the expected (III) schedule exhibits higher employment (75,000) than the baseline (I-31,000) and on-time (II-27,000) schedules.

EXECUTIVE SUMMARY

INTRODUCTION

A. OBJECTIVES

In its contract (No. 68-01-0553) with Arthur D. Little, Inc. (ADL), the Environmental Protection Agency (EPA) stated the objective of this study to be:

"To analyze the economic impact of environmental standards on the industries providing pollution abatement equipment to be required by both industry and government."

To fulfill that objective, it was further specified that the analysis should be divided into three parts, as follows:

- A characterization of the industry.
- An analysis of demand.
- An evaluation of economic impact.

The analyses of demand and derivative impact upon the pollution abatement equipment industry were to be carried out under the assumptions of three alternative futures:

Case I: Baseline

An extrapolation of pollution abatement activity assuming major environmental legislation had not been passed.

Case II: Federal Compliance Schedule

A simulation of pollution abatement activity to be expected from rigid enforcement of current legislation and standards.¹

Case III: Expected Compliance Schedule

An alternative simulation of the pattern of activity which ADL believes may more likely occur.

¹The legislative targets and related standards considered herein are those in force in mid-1972. Hence, the amendments to the Federal Water Pollution Control Act of October 1972 have not been integrated into our analysis.

B. SCOPE

In general, the pollution abatement equipment industry described in this report includes those companies which supply products and related services for the control of air and water pollution.²

Regionality was not viewed as critical to this analysis of the equipment portion of the pollution abatement industry. The leading suppliers are located in a representative sample of the largest metropolitan areas, and their customers are as widespread as urban population and manufacturing industry. Hence, our analysis has focused on a national market served by a national industry.

1. Air Pollution Control.

Our analysis of the air pollution control (APC) equipment industry is addressed to the control of large-scale emissions from stationary sources; it excludes the control of emissions from mobile sources, the alteration of fuels, and process improvements.

Air pollution control equipment is differentiated into its particulate removal and gaseous control segments. Particulate removal is considered in terms of traditional product lines: electrostatic precipitators, fabric filters, wet scrubbers, and mechanical collectors. Gaseous control equipment is separated into the emerging SO₂ control systems and the traditional devices for fume and odor control.

Instrumentation markets associated with the control and monitoring of stationary sources are considered separately. Finally, we examine the substantial association services provided by air pollution control equipment manufacturers: design, assembly, erection, and the supply of auxiliary equipment. However, those services which are supplied by the construction industry, although identified, have been excluded from our impact analysis.³

2. Water Pollution Control.

In our analysis, the most important distinction in the water pollution control (WPC) equipment business is between its municipal and industrial sectors. We have emphasized specialty equipment (i.e., that produced largely for WPC applications), giving specific attention to 15 major product areas. Instrumentation for water pollution control we analyzed separately. Although they are not, strictly speaking, an equipment item, we have also included in our analysis the specialty chemicals (and their related services) needed for water pollution control. The greater portion of water pollution control expenditures, that of facility construction, is included in the demand analysis and excluded from the impact analysis in this report.⁴

²Initially, the work was to address radiation control along with air and water pollution, but the lack of any meaningful statistics on equipment markets prevented our analyzing that market.

³The analysis of the impact of pollution legislation upon the construction services industry was covered in a concurrent study funded by EPA.

⁴*Idem.*

C. SOURCES OF INFORMATION

The information used in this study was gathered from many sources. Much of it, particularly that related to industry characteristics, was obtained from ADL staff members with knowledge and experience in the pollution control business. This information was supplemented during the study through personal contacts with leading companies and associations in the pollution control industry; with leading financial institutions and manpower recruiting firms; and with state agencies, the Department of Commerce, and EPA. We are indebted to more than 25 companies and their executives for their contributions and have also benefited from the cooperation of the Industrial Gas Cleaning Institute (IGCI), the Water Pollution Control Federation (WPCF), the Water and Wastewater Equipment Manufacturers Association (WWEMA), the Process Equipment Manufacturers Association (PEMA), and the National Sanitation Foundation (NSF).

I. THE INDUSTRY

A. ITS STRUCTURE

The major sectors of the pollution abatement equipment industry are:

- air pollution control equipment.
- water pollution control equipment.
- instrumentation for air and water.
- water pollution control chemicals.

By commonly accepted standards, these pollution industries are not overly concentrated. The concentrations in the APC and WPC equipment industries are typified by their specialty equipment sectors.

More than 300 companies participate in the APC equipment business (hardware plus associated services) estimated at \$466 million in 1971. The 4 leading suppliers of equipment account for about 35% of the market; similarly, the top 12 and 20 suppliers are estimated to account, respectively, for 60% and 70% of the total.

Although there has been a slight trend toward further concentration in the APC equipment industry by way of mergers and acquisitions, there is not yet cause for concern. Moreover, the advent of a sizeable SO_2 control market should contribute to a redistribution of the APC business among a larger number of firms.

More than 400 firms participate in a total business that encompasses both water pollution control and its more established counterpart, water treatment. The 4 volume leaders in this combined category hold about 20% of a market which totaled about \$475 million in 1971: about \$275 million for wastewater treatment and \$200 million for water treatment.

As associated services are much less a part of a supplier's business in water pollution control, our concentration analyses are based solely on the equipment market. Including the 4 leaders, the top 12 and top 20 firms probably account for 45% and 60%, respectively, of the combined market. There has been significant concentration in recent years: of the top 12 firms, 5 have been involved in major mergers or acquisitions. Yet, the water and wastewater treatment equipment business remains less concentrated than the APC equipment business. There is no reason to believe that an overly concentrated industry structure will present a major impediment to the near-term supply of needed pollution abatement systems.

B. ITS MARKETS

1. Domestic.

A customer-market of great concern in this study is municipal sewage treatment, because of its multi-layered structure of municipal governments, consulting engineering firms, contractors, local health authorities, state health departments, and federal authorities. One

effect of this marketing structure is an extended delay (3 to 5 years) between decision and equipment delivery. A second – and maybe more important – effect is the pressure on these parties to protect their respective positions by conservative decision-making. As a result, the municipal WPC market will be slow to respond to federal compliance pressures and to technological change. Moreover, the difficulties of selling to these markets reduces corporate profits and thereby incentives in serving it.

The pollution control customer is a reluctant one, primarily because his investment can only subtract from his profitability. In simple terms: *if he is not legally forced to invest he will not, and if he is he will.* This customer characteristic reflects the major link between the rate of pollution control investment and the degree of federal enforcement.

2. Foreign.

Theoretically, the U.S. lead in environmental legislation over the rest of the world could present an opportunity for significant export of technological know-how. However, in examining the most likely of the near-term foreign markets – i.e., Western Europe and Japan – to determine the magnitude of this export potential, we find that the actual potential is not encouraging. Technologically, we may enjoy a slight advantage, but the markets are not only small but effectively protected against import competition. Of the 1969 import (U.S. export) markets in Western Europe, for example, the U.S. share in APC equipment was less than 15%, but as much as 40% in water treatment equipment. Even at that, our export volumes in each case represented 2% or less of our domestic market. Until now, the participation of U.S. producers in foreign markets has been concentrated in licensing agreements, affiliations, and partial ownership of foreign suppliers. As a result, foreign markets (and foreign competition) do not play a role in our analyses of demand and economic impact.

C. ITS PERFORMANCE

Because of the great publicity about pollution control, the business has become a glamour industry to investors, its participants and its potential new entrants. Its performance, however, has thus far been a relative disappointment. Given this history, we examined the financial statistics of the industry to assess its attractiveness to both its leading companies and to potential new entrants. We were concerned that if the business were not sufficiently attractive, there might be a problem in attracting future investment. After considerable examination, we believe that the pollution abatement equipment business is attractive enough to encourage the development of as much long-term supply as may be needed through 1980, for several reasons.

First, the profit margins enjoyed by pollution control companies on their pollution businesses have generally exceeded the margins received in their other businesses.

Second, comparing the return on assets enjoyed by companies for which pollution control is a significant activity (greater than 5% of sales) to those companies in which pollution control is a minor activity, we found that the former slightly out-performed their less involved competitors.

Third, comparing the return on assets of companies "in" the pollution business to their broader SIC industries to determine whether similar companies would be attracted to the business, we found that the performance of pollution companies was generally above that of its SIC neighbors.

Finally, examining the returns of selected companies in two industries which have indicated strong interests in entering the pollution business — the chemical and aerospace industries — we found that the returns of WPC specialty chemical companies were greater than the returns of major chemical firms. Also, average returns of the pollution control equipment suppliers were more attractive than the average returns of leading aerospace companies.

Since the pollution abatement industry now seems to be in severe overcapacity, its profitability will become even more attractive with a return to normal or higher operating rates.

In summary, although the returns in the pollution business have appeared low to many observers, we find no cause for concern about a shortage of investment in the business.

II. THE DEMAND

The major task in analyzing the market for the pollution abatement equipment industry was converting gross estimates of needed pollution control expenditures into an aggregate demand for products and services and distributing those expenditures over time. Specifically, the objectives of our analysis were:

- to determine the aggregate demand (in constant dollars) for pollution abatement equipment over the period 1972-80.
- to determine that portion of aggregate demand which represents a business for equipment manufacturers.
- to determine component markets for major product lines.

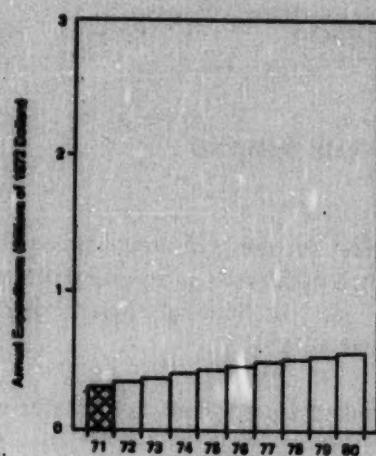
These demand analyses were performed for each of the following market segments: air pollution control, municipal sewage treatment, industrial wastewater treatment, and water treatment chemicals. In each segment, the demand was forecasted under the three alternative futures: Case I - Baseline; Case II - Federal Compliance Schedule; and Case III - Expected Compliance Schedule. (The results of these analyses are summarized in Table 1).

A. AIR POLLUTION CONTROL

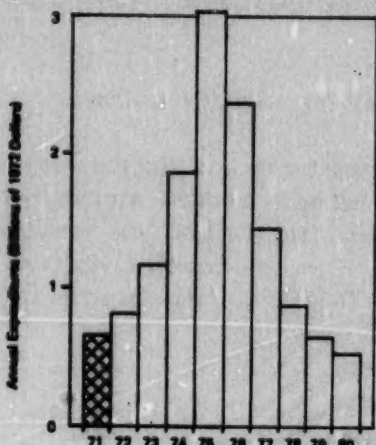
The aggregate needs for air pollution control expenditures were developed from industry studies sponsored by EPA for its annual report to Congress, the *Economics of Clean Air*. This aggregate investment need of \$12.8 billion is similar to numbers published elsewhere by EPA and the Council on Environmental Quality. Estimates of current markets in particulate and gaseous control hardware (\$233 million in 1971) were based on adjusted figures from the Industrial Gas Cleaning Institute. The current product mix was estimated from IGCI figures, while the changes in product mix over the decade were based on the views of ADL staff.

1. Case I - Baseline.

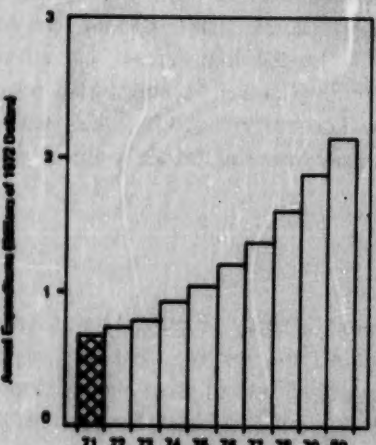
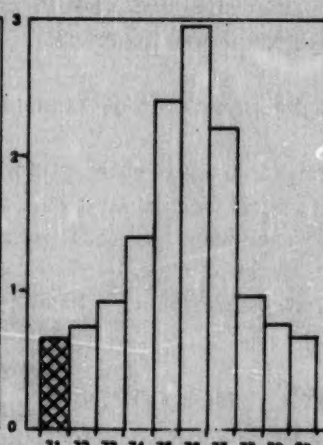
The projection of baseline equipment activity (Figure 1) was developed by choosing a base year, 1963, after which major legislation began to affect APC expenditures. The market level in 1963 was first increased at the actual rate of gross private domestic investment from 1963-71 (7.6% per year). The projection of that index for the 1972-80 period was taken from ADL's Input/Output Model of the National Economy. Thus, in Table 1 and Figure 1 the baseline growth begins with a 1971 baseline volume (extrapolated from 1963 activity) and is extrapolated at 5.4% per year through 1980.



CASE I: BASELINE



CASE II: FEDERAL COMPLIANCE SCHEDULE



CASE III: EXPECTED COMPLIANCE SCHEDULE



Source: Arthur D. Little, Inc. estimates.

FIGURE 1 AIR POLLUTION CONTROL COMPARATIVE EXPENDITURES, 1972-80

2. Case II - Federal Compliance Schedule.

A federal compliance deadline of mid-1975 (consistent with the deadlines for compliance to primary standards) was used as the prime pressure point around which to build the Case II scenario. This schedule was adjusted to reflect the process of granting waivers to selected states; otherwise, a more dramatic shape than shown in Figure 1 would have resulted.

The changing status of SO₂ control technology made it imperative to distinguish between two situations in both Cases II and III:

(a) Present Gaseous Control Technology

Assumes further difficulties in developing and proving current candidate technologies.

(b) Adequate Gaseous Control Technology

Assumes availability of proven technologies in time for 1975-77 installations.

One concern with Case II is the implied creation of an over-stimulated pollution control industry which, after its fall from peak demand, would become over-populated, and unprofitable.

3. Case III - Expected Compliance Schedule.

Case III (Figure 1) adjusts the Federal Compliance Schedule to better reflect the historical realities of pollution control enforcement, the historical rate of market growth, and a prescription for a healthier supplying industry. Again, projections are made under the dramatically different situations of: (a) further difficulties in developing SO₂ control technology and (b) availability of proven SO₂ control systems early in the forecast period. The result in both situations is a forecast of activity which does not begin to really pick up until 1974, that peaks with the 1975 deadlines, and then recedes to lower but still attractive growth rates through 1980. If new legislation does not increase APC targets, these expected compliance schedules will also result in a falling market after 1980.

B. MUNICIPAL SEWAGE TREATMENT

Aggregate needs for municipal sewage plants and ancillary facilities were developed from figures in EPA's annual *Economics of Clean Water*. Current market and product mix estimates were based on surveys made by the Department of Commerce. Projections of changes in product mix were developed by the ADL staff with assistance from our contacts in the industry. On a constant dollar basis, the recent history of municipal expenditures has been disappointing. The average annual growth since 1965 has only been 0.6%/year, down from a 1958-65 average growth of 7.6% per year. This plateau of municipal demand has resulted from the waiting by municipalities for promised Federal assistance - assistance

which has not been up to those expectations. The aggregate demand for total municipal sewage system expenditures between 1972 and 1980 is estimated at \$27 million. The mix of expenditures between treatment plants, ancillary facilities, and collection systems were further adjusted to reflect EPA's survey of specific municipal needs. The results of the demand analyses under the three alternative futures are shown in Table 1 and Figure 2.

1. Case I - Baseline.

The starting line for our baseline projection was 1965, which marked the first promise of significant federal funds for municipal construction (and correspondingly marked the beginning of a plateau in municipal spending which only recently has been exceeded). From the 1965 level of expenditures, the baseline was updated to 1971 by a multiplier (about 1.04) corresponding to the growth in municipal water usage over that period. Similar multipliers were used to grow the baseline over the 1971-80 period. Figure 2 shows that the baseline exceeds the level of activity in Cases II and III until 1974, thus emphasizing the impact which the municipal waiting game has had upon not only the progress of our national water pollution control program but upon the operating rates and profits of the WPC equipment industry.

2. Case II - Federal Compliance Schedule.

We anticipate at least some flexibility in waiving compliance to contemplated 1976 water effluent standards in selected situations, particularly in recognition of the long delay between federal grant and final equipment delivery in the municipal market. As in air pollution control, the federal compliance schedule portrays a fast growing industry which peaks quickly and then falls to a presumed situation of low operating rates and low profits.

3. Case III - Expected Compliance Schedule.

Our projection of the growth of the municipal sewage treatment demand looks to a continuation of lower growth rates in annual investment through 1973, an acceleration of expenditures in 1974-76, and the tapering off to an acceptable growth rate through 1980. Hidden within the curves in Figure 2 are the greater growth rates of specialty equipment indicated in Table 1. These higher growth rates for the equipment proportion of the total are due to changes in product mix and the relative proportion of total investment represented by treatment plant expenditures. From the point of view of either specialty equipment or total expenditures, the pattern of growth in Case III presents a more favorable future for the WPC equipment industry. However, Case III will also suffer a declining market after 1980, providing new legislative targets are not set by then.⁵

⁵The passage of the 1972 amendments to the Federal Water Pollution Control Act affect more the source of monies for municipal sewage treatment than targets of control. Thus, the backlog of needs remains roughly the same (\$27 billion) as in this analysis.

TABLE 1

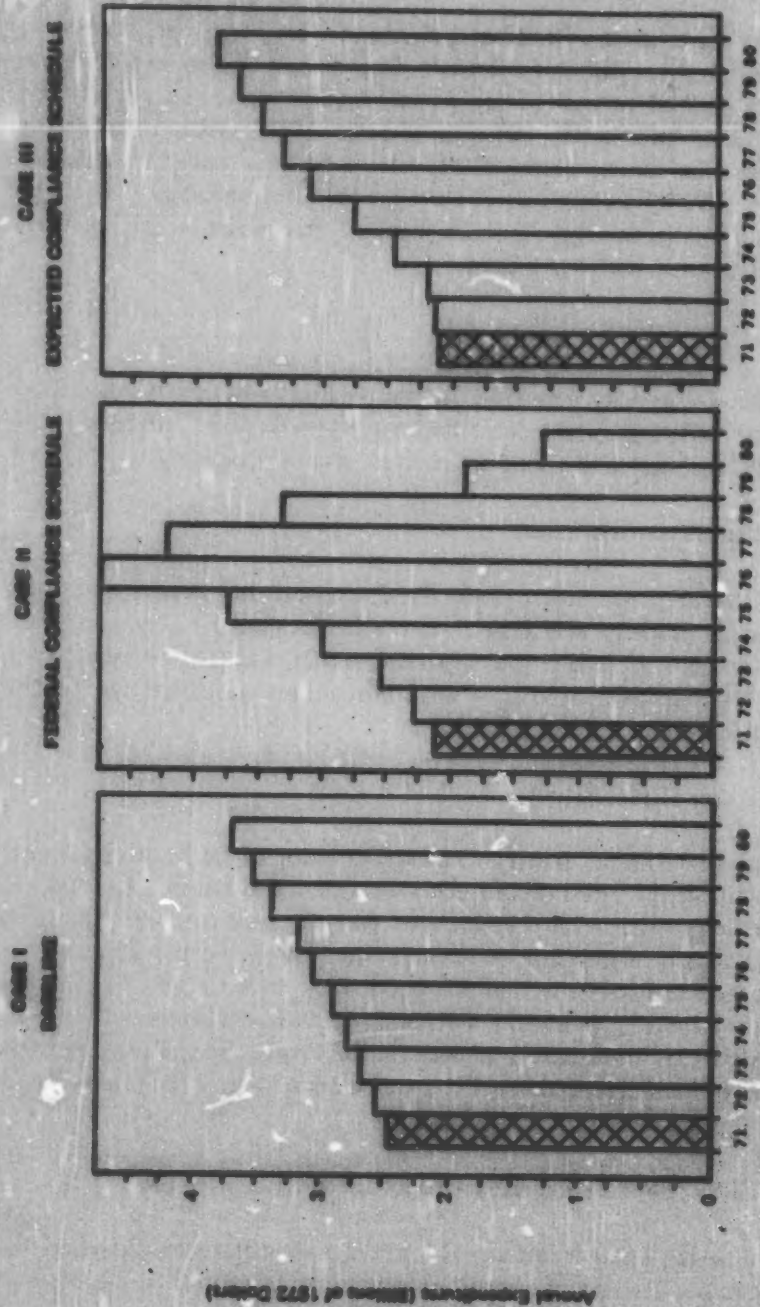
ESTIMATED POLLUTION ABATEMENT EQUIPMENT SHIPMENTS, 1972-80

		Annual Shipments (Millions of 1972 Dollars)										Growth (%/year)	
		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
A. AIR POLLUTION CONTROL													
Case I: Baseline													
Particulate Control		104	111	117	124	130	137	144	152	160	167	5.4	5.4
Gaseous Control		10	11	11	12	13	14	14	15	15	16	5.4	5.4
Subtotal		114	122	128	136	143	151	158	167	175	183	5.4	5.4
Instrumentation		8	8	8	9	9	10	10	11	11	12	5.4	5.4
Case IIa: Federal Compliance Schedule													
Particulate Control		201	247	361	570	935	530	269	151	97	78	46.9	-39.2
Gaseous Control		42	50	66	95	152	243	164	99	76	64	37.9	-15.9
Subtotal		243	297	427	665	1087	773	433	250	173	142	45.4	-33.5
Instrumentation		15	28	40	62	102	80	49	29	21	17	61.4	-30.2
Case IIb: Federal Compliance Schedule													
Particulate Control		201	221	251	326	496	220	158	126	99	80	25.3	-30.6
Gaseous Control		42	50	76	135	262	525	374	135	106	94	37.9	-18.5
Subtotal		243	271	327	461	758	745	532	261	205	174	32.9	-25.5
Instrumentation		15	25	31	43	71	70	50	25	19	16	47.5	-25.8
Case IIIa: Expected Compliance Schedule													
Particulate Control		201	214	234	281	310	340	357	395	441	471	11.4	8.7
Gaseous Control		42	46	53	62	70	86	108	142	171	208	13.6	24.6
Subtotal		243	260	287	343	380	426	465	537	612	679	11.8	12.3
Instrumentation		15	20	25	31	40	46	53	61	70	80	27.7	14.9
Case IIIb: Expected Compliance Schedule													
Particulate Control		201	214	234	281	310	320	285	153	104	74	11.4	-24.9
Gaseous Control		42	51	63	86	113	147	199	292	327	344	28.1	24.9
Subtotal		243	265	297	367	423	467	484	445	431	418	14.9	-0.2
Instrumentation		15	20	25	31	40	46	53	61	70	80	27.8	14.9

TABLE 1 (CONTINUED)

ESTIMATED POLLUTION ABATEMENT EQUIPMENT SHIPMENTS, 1972-80

		Annual Shipments (Millions of 1972 Dollars)										Growth (%/year)	
		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
B. MUNICIPAL SEWAGE TREATMENT													
Case I: Baseline													
Specialty Equipment		96	100	104	109	114	119	125	132	138	145	4.3	5.0
Instrumentation		11	12	12	13	13	14	15	15	16	17	4.3	5.0
Case II: Federal Compliance Schedule													
Specialty Equipment		110	126	159	221	292	368	390	211	113	73	27.6	-24.4
Instrumentation		17	21	28	39	54	78	65	52	23	15	33.0	-13.0
Case III: Expected Compliance Schedule													
Specialty Equipment		110	114	123	152	186	222	239	255	277	293	14.1	9.5
Instrumentation		17	19	21	26	33	42	48	54	62	69	17.9	13.9
C. INDUSTRIAL WASTEWATER TREATMENT													
Case I: Baseline													
Specialty Equipment		56	59	63	66	69	73	77	81	86	91	5.4	5.4
Instrumentation		13	14	14	15	16	17	18	19	20	21	5.4	5.4
Case II: Federal Compliance Schedule													
Specialty Equipment		172	192	211	228	239	248	151	85	75	63	8.6	-23.4
Instrumentation		26	31	35	38	42	44	28	17	14	13	12.7	-21.0
Case III: Expected Compliance Schedule													
Specialty Equipment		172	184	197	207	213	217	148	124	80	73	5.5	-19.3
Instrumentation		26	30	32	34	36	38	36	23	16	15	8.5	-16.1
D. WATER AND WASTEWATER TREATMENT CHEMICALS													
Case I: Baseline													
Bulk Chemicals		122	127	132	138	143	148	155	162	170	179	4.0	4.6
Specialty Chemicals		271	282	294	306	318	332	345	360	376	392	4.1	5.5
Case II: Federal Compliance Schedule													
Bulk Chemicals		125	132	139	147	155	163	171	178	185	191	5.5	4.3
Specialty Chemicals		275	289	305	321	339	358	375	391	405	419	5.4	4.3
Case III: Expected Compliance Schedule													
Bulk Chemicals		125	132	139	145	152	160	169	176	184	191	5.5	4.7
Specialty Chemicals		275	289	305	320	336	354	371	388	403	418	5.1	4.5



Source: Arthur D. Little, Inc. estimates.

FIGURE 2 MUNICIPAL SEWAGE TREATMENT
COMPARATIVE EXPENDITURES, 1972-80

C. INDUSTRIAL WASTEWATER TREATMENT

Among the sectors we have studied, reliable information on industrial wastewater treatment expenditures is the most difficult to obtain. Department of Commerce surveys were used for estimating the level of current equipment shipments and the product mix therein. On the basis of that information, we estimated the 1971 market for specialty equipment and instrumentation to be about \$192 million (current dollars). Aggregate demand estimates for the 1972-80 period were, with slight modifications, based on EPA's *Economics of Clean Water* reports. The aggregate demand for industrial expenditures estimated therefrom for the period was \$9.7 billion.

1. Case I - Baseline.

Again, 1965 was selected as the base year. The baseline (Figure 3) was constructed using the level of shipments in 1965, a growth index reflecting industrial plant investment (the same 5.4% used in the APC analysis), and a constant product mix of equipment.

2. Case II - Federal Compliance Schedule.

Since industry has a faster response time to federal enforcement than municipalities, we were able to assume that the majority of industrial wastewater treatment will be taken care of by the 1976 deadline (Figure 3). Indeed, the apparent level of expenditures by industry in 1971 are already so high that it took only a small growth rate to achieve the needed expenditures by 1975 (about 7.2%).

3. Case III - Expected Compliance Schedule.

We see no great difficulty in having industry accomplish most of the backlog (as now measured) by 1976. This is partly based on our estimates that industrial expenditures are already at a level (\$1.2 billion) which, with only a modest growth, could reach the estimated target by 1976-77. As a result, in industrial wastewater treatment, the possibilities of a declining market during the 1970's exist in Case III just as they do in Case II. This implies that either industry is close to solving its water pollution problems under present objectives⁶ or that the costs of control have been greatly underestimated. Again, specialty equipment expenditures will grow at a faster rate than total expenditures because of the trend toward advanced treatment.

D. WATER AND WASTEWATER TREATMENT CHEMICALS

This is the only case in which we have considered in detail a non-equipment item and one that is tied to operating rather than to investment expenditures. In projecting the demand

⁶Excluding the implications of the amendments to the Federal Water Pollution Control Act of October 1972.

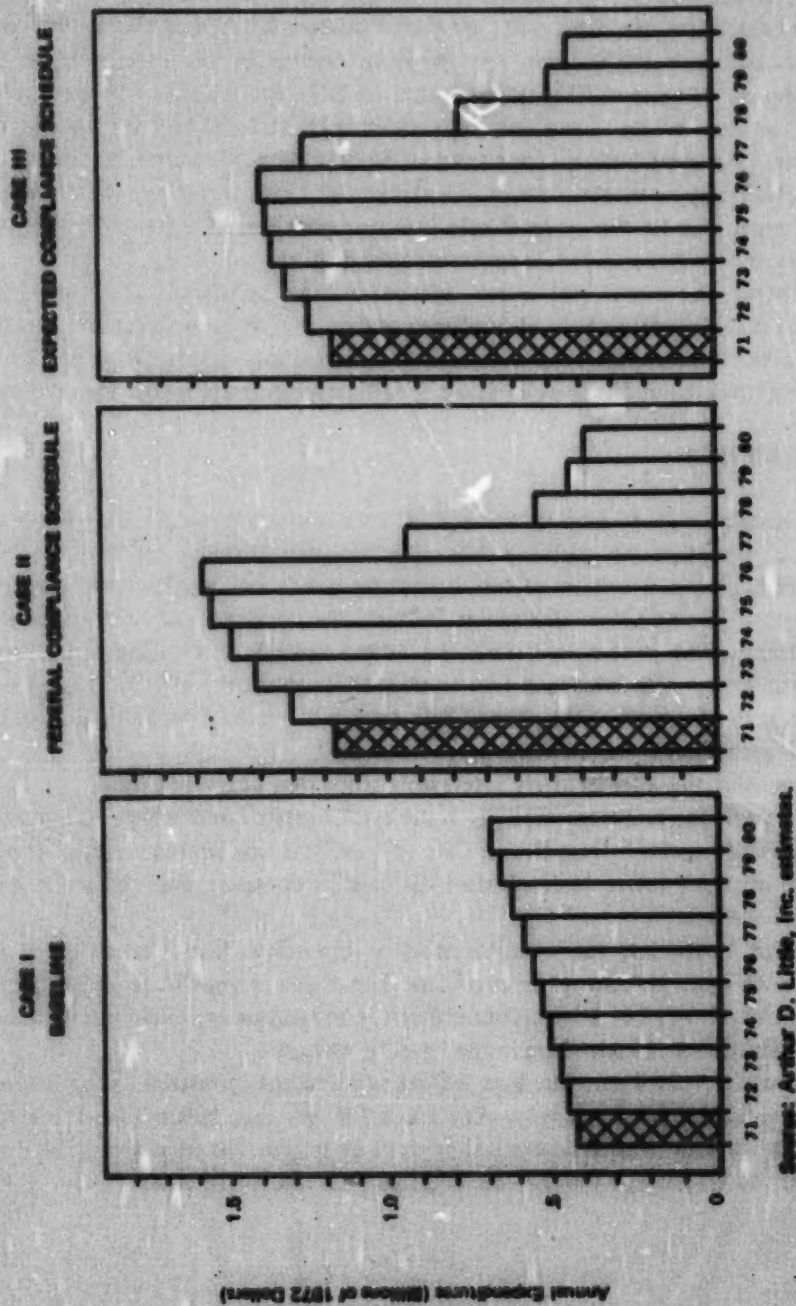


**FIGURE 3 INDUSTRIAL WASTEWATER TREATMENT
COMPARATIVE EXPENDITURES, 1972-80**

for wastewater treatment chemicals, we have tied its growth to the cumulative growth of investment. We have also considered this business in terms of the larger business of specialty chemical companies which, for the most part, are water treatment-based at this time. Our estimates of recent and current markets for specialty chemicals are based on ADL experience and producers' judgments. We estimate that in 1971 the markets for chemicals (bulk and specialty) in wastewater treatment were about \$75 million; to this, we added \$325 million of water treatment business for a total of \$400 million. We increased chemical consumption proportionately with the rate of installation of both water and wastewater facilities. The only exception to this general rule was our giving a 25% greater bonus to specialty chemicals in sewage and industrial wastewater applications.

For chemical demand, there was not much difference between Cases I, II, and III. Chemical usage is not tied directly to federal deadlines, although their growth can accelerate somewhat as construction put-in-place increases near those deadlines. Even after a deadline has passed cumulative investment enables chemicals to still experience an increasing market.

E. COMPARATIVE REVIEW

In all of the industrial sectors except water and wastewater chemicals, the Federal Compliance Schedule threatens to create a booming industry through 1975 or 1976, thereafter quickly falling to a situation of low operating rates, low profits, and venture failures. Our Expected Compliance Schedules reflect the realities of enforcement, technology, and construction delays and have the added appeal of creating a healthy pollution abatement industry with attractive growth rates throughout the 1970's. It must be noted that after 1980, the Expected Compliance Schedules will result in declining demands and operating rates — providing legislative targets are not raised.

Each of the sectors embodies a particularly interesting story that bears repeating.

In air pollution control, the major uncertainty is the availability of technology to control SO₂ emissions. As a result, in both Case II and Case III, we have considered results of two very different situations: (A) where technological difficulties continue and (B) where an adequate technology is proven.

In municipal sewage treatment, the headline story is the effect that recent delays in municipal spending have upon the comparison of Case I to Cases II and III. In short, these projections indicate that it will be 1974 before either the federal or expected compliance schedules catch up with the rate of spending in the baseline scenario.

In industrial wastewater treatment, our best estimates of recent industrial expenditures indicate that those expenditures cannot grow very much for very long before the estimated backlog of needs is exhausted. This indicates either that, under current objectives, there is not much that remains to be done or that the backlog has been underestimated.

III. THE IMPACT

A. APPROACH

Our impact analysis has focused upon balancing our estimates of demand against the supply capabilities of the pollution abatement equipment industry. This analysis was hindered by a serious lack of reliable data on industry supply capacities when received as physical plant and equipment. The problems presented by this lack of statistical data on industry supply capabilities were reduced by our consideration of a broader definition of capacity. From economic theory we have taken a production function approach and adapted it to the available data on supply capabilities in the industry. In this context, "supply" is looked upon in terms of not only physical plant and equipment (the input of capital) but also in terms of the input of labor and materials.

We believe both the statements of the industry and the limited amount of secondary statistics which show that there is now a substantial overcapacity of physical plant and equipment. Furthermore, given the heavy dependence of the pollution abatement industry on the broader metal fabricating industry, it is difficult to define its capacity. Therefore, we sought to quantify only the general levels of operation.

Combining traditional production theory with basic accounting practice, we worked from the basic identity that total revenue equals the sum of total payments to labor, capital, and materials. We estimated the proportions of these three production factors (as a part of total revenues) from data on selected SIC industries in the *Census of Manufactures* and from contacts with leading manufacturers. We then surveyed three to five companies in each of the industry sectors (also employment agencies) to determine the supply elasticities of different kinds of labor and materials. This survey was not an exhaustive one but was made primarily to assure that the supply elasticities used in this analysis were of the right magnitude. Separately, we made an analysis of the elasticity of interest rates for corporate borrowing over time, in order to ascertain the effects of increased capital costs upon the final price to customers. These analyses of the capital markets for this industry were confirmed through conversations with leading financial institutions.

The elasticity information from these surveys was then combined into individual supply curves for skilled labor, production labor, materials, and capital. These supply curves were used as annual short-run supply curves, relating increased cost premiums against increases in factor requirements over a given year.

A major simplifying assumption was that the short-run supply curves (actually developed for 1972) would be characteristic of the short-run factor supply markets for the rest of the decade. The second assumption was that, except for operating effects, the *Census of Manufactures* breakdowns of the factors of production will also remain constant.

The supply curves were generally quite elastic. Supply curves for materials were more elastic than those of production labor, which in turn were more elastic than the skilled labor curves. Our supply curves for borrowed capital were actually stepwise curves indicating that above a certain annual increase in capital requirements the interest rate would jump from a lower to a higher level.

Our objectives in balancing our demand forecasts with our empirical supply curves were to indicate what price increases would result if direct cost increases created by supply constraints were passed onto the customers. In short, we measured a *cost push* and not directly a forecast of prices. This cost push reflects factor scarcity. The forecast of actual prices would have to include other important considerations besides factor scarcity: the effects of operating rates upon the fixed cost loads, the relative price elasticity to the quality of product and service performed, and the prediction of corporate policies on pricing in times of short- and over-supply.

We have analyzed the economic impact upon the different industry sectors in terms of the pollution abatement and closely-related businesses of the leading manufacturers. Since the gaseous control market is unique both in shape over time and in competitive membership, its analysis was separated from particulate control. As the companies involved in water pollution control equipment are equally involved in water treatment markets, we included forecasts of water treatment equipment demand in the calculation of year-to-year growth factors. We combined air and water instrumentation demand because of a substantial overlap of companies between those two markets and the probability that the overlap will increase in the future. In chemicals, we analyzed only the expected compliance schedule case since the three schedules for that industry were very similar. Again, we combined both water and wastewater treatment demand in analyzing the impact upon that industry.

B. RESULTS

In the particulate control equipment segment of the APC market, the potential cost push inflation (Table 2) is greater under the Federal Compliance Schedule (Case II) and the assumption (a) of present gaseous control technology. The Federal Compliance Schedule puts more pressure upon supply than the Expected Compliance Schedule (Case III). An assumption (b) of the development of adequate gaseous control technology reduces the demand for particulate control equipment and, consequently, the supply pressure on prices.

In the gaseous control equipment market, the inflation (Table 3) is greater under Case II and the assumption (b) of adequate gaseous control technology. With the latter assumption, gaseous control activity is allowed to progress faster, putting more pressure on costs and prices.

1. Price Effects.

The water pollution control equipment business (Table 4) was the only one in which the baseline demand schedule was of any significance. There, the baseline and expected compliance schedules resulted in only a 0.3% average inflation compared to 0.8% for the federal compliance schedule. The inflation effects for both the water pollution control equipment business and the water chemicals business (Table 5) were dampened considerably by the addition to the related demand for water treatment.

The results of these analyses which take into account factor supply elasticities and operating rate conditions are combined in a kind of composite supply curve for each industry as illustrated in Figures 4 and 5. These are not true supply curves in the sense of

TABLE 2

COMPARATIVE INFLATIONARY IMPACT OF CASES II AND III -- AIR POLLUTION CONTROL

PARTICULATE CONTROL EQUIPMENT

Case II - Federal Compliance Schedule		Case III - Expected Compliance Schedule	
(a) Present Gaseous Control Technology	(b) Adequate Gaseous Control Technology	(a) Present Gaseous Control Technology	(b) Adequate Gaseous Control Technology
Cumulative Index	Cumulative Index	Cumulative Index	Cumulative Index
1972	1.0101	1.0033	1.0027
1973	1.0437	1.0060	1.0072
1974	1.1007	1.0146	1.0171
1975	1.1443	1.0213	1.0223
1976	1.1395	1.0279	1.0260
1977	1.1258	1.0309	1.0238
1978	1.1192	1.0377	1.0213
1979	1.1115	1.0472	1.0213
1980	1.1049	1.0527	1.0213
Inflated Demand			
1971-1980 (Millions			
1972 Dollars)	\$3794.3	\$3337.8	\$2212.2
† Base Demand			
1971-1980 (Millions			
1972 Dollars)	\$3439.0	\$3244.0	\$2176.0
- Average Inflation	10.3%	2.9%	1.7%

TABLE 3

COMPARATIVE INFLATIONARY IMPACT OF CASES II AND III -- AIR POLLUTION CONTROL

GASEOUS CONTROL EQUIPMENT

Case II - Federal Compliance Schedule		Case III - Expected Compliance Schedule	
(a) Present Gaseous Control Technology	(b) Adequate Gaseous Control Technology	(a) Present Gaseous Control Technology	(b) Adequate Gaseous Control Technology
Cumulative Index	Cumulative Index	Cumulative Index	Cumulative Index
1972	1.0094	1.0080	1.0044
1973	1.0240	1.0395	1.0104
1974	1.0691	1.0893	1.0176
1975	1.1089	1.1363	1.0251
1976	1.1552	1.1911	1.0420
1977	1.1658	1.1990	1.0596
1978	1.1530	1.1852	1.0847
1979	1.1455	1.1772	1.0965
1980	1.1380	1.1694	1.1167
Inflated Demand			
1971-1980 (Millions			
1972 Dollars)	\$1176.2	\$2084.7	\$1054.5
+ Base Demand			
1971-1980 (Millions			
1972 Dollars)	\$1051.0	\$1799.0	\$ 988.0
= Average Inflation	11.9%	15.9%	6.7%
			13.5%
			\$1888.8
			\$1664.0

TABLE 4

COMPARATIVE INFLATIONARY IMPACT OF CASES I, II AND III

WATER POLLUTION CONTROL EQUIPMENT

	<u>Case I</u>	<u>Case II</u>	<u>Case III</u>
	<u>Baseline</u>	<u>Federal Compliance Schedule</u>	<u>Expected Compliance Schedule</u>
	<u>Cumulative Index</u>	<u>Cumulative Index</u>	<u>Cumulative Index</u>
1972	1.0007	1.0013	1.0006
1973	1.0013	1.0026	1.0013
1974	1.0020	1.0046	1.0026
1975	1.0026	1.0090	1.0038
1976	1.0033	1.0131	1.0054
1977	1.0039	1.0141	1.0054
1978	1.0046	1.0100	1.0054
1979	1.0053	1.0087	1.0054
1980	1.0060	1.0087	1.0059
Inflated Demand 1971-1980 (Millions 1972 Dollars)	\$1909.4	\$3677.0	\$3648.0
+ Base Demand 1971-1980 (Millions 1972 Dollars)	\$1903.0	\$3635.4	\$3636.0
- Average Inflation	0.3%	0.8%	0.3%

TABLE 5

COMPARATIVE INFLATIONARY IMPACT OF CASES II AND III
INSTRUMENTATION AND SPECIALTY CHEMICALS

	<u>Instrumentation</u>		<u>Specialty Chemicals</u>
	<u>Case II</u>	<u>Case III</u>	<u>Case III (and II)</u>
	<u>Federal Compliance Schedule</u>	<u>Expected Compliance Schedule</u>	<u>Expected and Federal Compliance Schedules</u>
	<u>Cumulative Index</u>	<u>Cumulative Index</u>	<u>Cumulative Index</u>
1972	1.0073	1.0036	1.0003
1973	1.0294	1.0063	1.0006
1974	1.0494	1.0129	1.0009
1975	1.0699	1.0225	1.0012
1976	1.0599	1.0253	1.0016
1977	1.0554	1.0287	1.0020
1978	1.0472	1.0287	1.0031
1979	1.0353	1.0312	1.0038
1980	1.0284	1.0355	1.0045
Inflated Demand 1971-1980 (Millions 1972 Dollars)	\$1175.3	\$1144.0	\$3466.0
+ Base Demand 1971-1980 (Millions 1972 Dollars)	\$1123.0	\$1118.0	\$3459.0
- Average Inflation	4.6%	2.3%	.2%

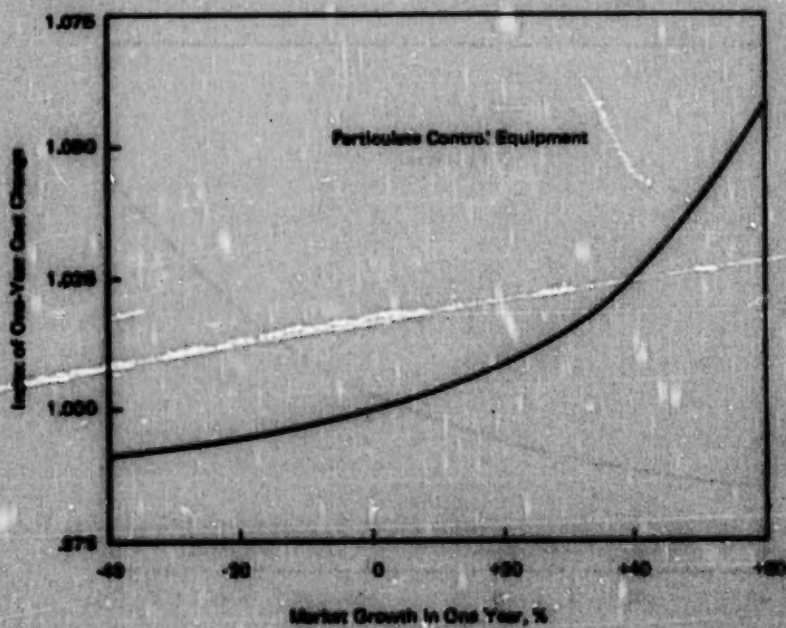
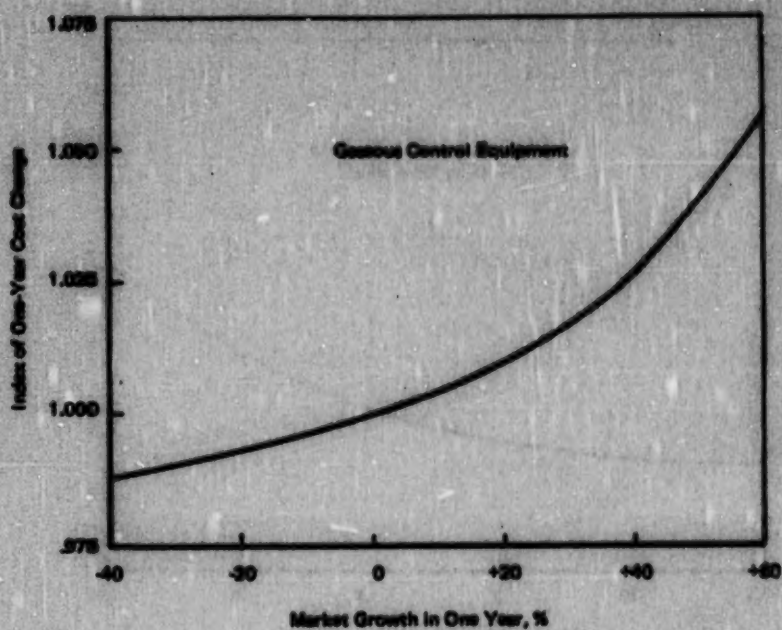


FIGURE 4 EFFECTIVE "SUPPLY" CURVES
Air Pollution Control

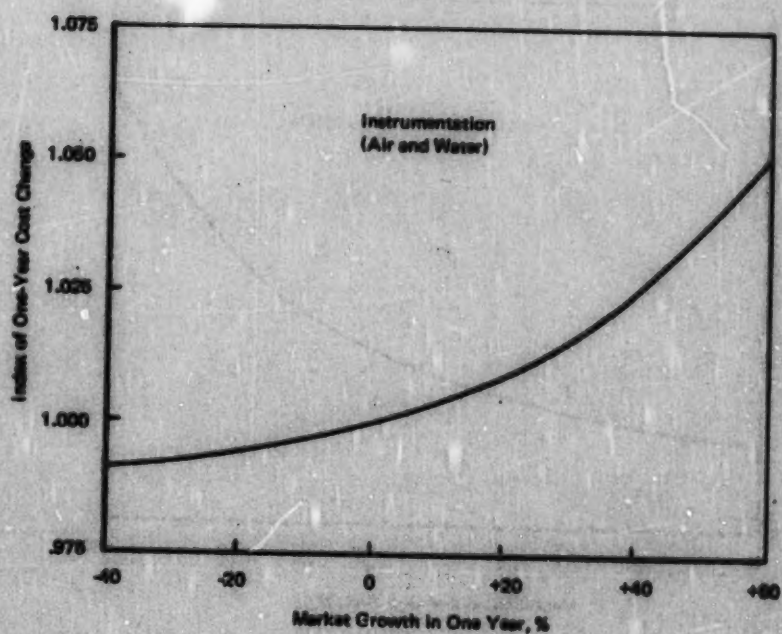
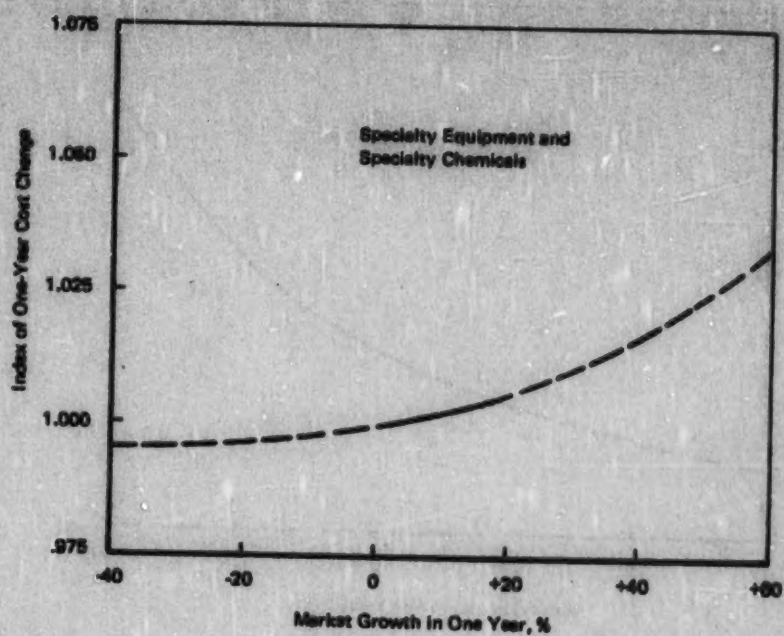


FIGURE 5 EFFECTIVE "SUPPLY" CURVES
Water Pollution Control

the ones we used as inputs to the analysis. They simply summarize a plot of the results of the price impact analysis in the different industries. In air pollution control (Figure 4), the resulting supply curves are the most elastic of the group, reflecting the higher growth rates, the more dramatic effects of federal deadlines, and somewhat greater input elasticities. These elasticities range from 20-25 (in the 0-20% growth range) to 10 (in the 20-40% range) to 5 (in the 40-60% range). The top of Figure 5 reflects the much higher elasticity (40, in the 0-20% range) in the range of growth rates developed in both water pollution control equipment and chemicals.

2. Employment Effects.

The lack of detailed studies of the manpower requirements in the pollution field for equipment suppliers and the smallness of our own sample of manufacturers' estimates of the breakdown of the types of manpower they utilize prevented us from statistically analyzing manpower requirements in detail. Based on average sales per employee ratios for leading companies in the business and the demand estimates we have developed, estimates of the gross manpower requirements for 1972, 1975, and 1980 are illustrated in Table 6.

In Case III, the total employment across the five industries is expected to increase from 35,000 people to 49,000 people (by 40%) from 1972-75 and to 75,000 people (210% of the 1972 level) by 1980. This compares to more than 210,000 employed in 1967 in the four-digit SIC industries encompassing these pollution abatement industries. Employment in Case II is projected to increase to 100,000 people in 1975 (up about 160% from 1972) but then decline to 27,000 people (less than current levels) by 1980 -- within a group of four-digit SIC industries that employed over 210,000 in 1967.

It is clear that federal legislation has had a positive employment impact when you compare the estimate of 35,000 people in 1972 under expected compliance schedules to the estimated 21,000 people under baseline conditions (67% greater). By 1975, the expected compliance schedule corresponds to an employment almost exactly twice that of baseline conditions, and by 1980 is nearly two and one-half times as great.

TABLE 6

INDUSTRY PERSONNEL REQUIREMENTS, COMPARISON OF THREE CASES, 1972-80

Industry Category	Case	1972			1973			1980		
		I	II	III	I	II	III	I	II	III
And 4M Sales/ Employee Ratio										
APC Equipment- Particulars ^a 30.1	Sales (1980) Employee	207 6,000	449 14,900	380 12,900	242 8,040	1,693 56,200	563 18,700	312 10,400	142 4,700	854 28,400
APC Equipment- General ^a 32.4	Sales Employee	30 926	100 3,090	91 2,800	34 1,050	328 10,100	153 4,720	44 1,360	182 5,610	546 16,830
WPC Equipment- 32.5	Sales Employee	159 4,890	318 9,780	298 9,170	183 5,630	531 16,303	399 12,300	236 7,260	136 4,180	364 11,300
Instrumentation 29.9	Sales Employee	34 1,630	80 3,030	69 3,300	38 1,900	198 9,470	109 5,220	50 2,390	45 2,150	166 7,300
WPC-Spec. Chem. 41.0	Sales Employee	282 6,000	289 7,050	269 7,050	318 7,760	339 8,270	336 8,200	392 9,560	419 10,200	418 10,200
Total Employees		21,200	38,650	35,220	24,280	100,340	49,140	30,970	26,840	74,650

^a Corresponds to demand projections for APC equipment in situation (a) assuming continued technological difficulties in candidate SO₂ control technologies.

SOURCE: Arthur D. Little, Inc. estimates.

IV. RECOMMENDATIONS

A. DATA NEEDS

- Association surveys of the production capacity (physical plant) available to the pollution equipment industries with emphasis upon the definition of capacity and the complementary role of the broader metal fabrication industry.
- Cooperative sponsorship with the Department of Commerce of surveys of equipment shipments for air or water pollution abatement.
- Studies with greater focus upon the operating and maintenance (O&M) costs of pollution control.
- In future cost-of-control studies, the development of aggregate costs for an industry on the basis of a typical mix of approaches rather than on general application of one typical approach.
- In future cost-of-control studies, the development of general schemes for relating costs to levels of treatment.
- Collaboration with Department of Commerce to more clearly define the placement of pollution abatement equipment items within the next *Census of Manufactures*.

B. FURTHER ANALYSES

- Updating of the demand and impact analyses in this report as the implied costs of new standards become better known, i.e., for the New Source Performance Standards under the Clean Air Act of 1970 or the effluent limitation guidelines under the 1972 Amendments to the Federal Water Pollution Control Act.
- Study of manpower requirements, both in skills and numbers, of the pollution equipment industry.
- Development of a supply-warning system relating environmental standards, derivative demand, the health of the economy, the balance of trade, and system delays to the production, financial, raw material, manpower, and technological resources of the pollution equipment and construction industries.

C. POLICY IMPLICATIONS

- The expectation of promised action has been a major cause of the present overcapacity in the pollution control industry. To the degree that standards and deadlines are, first, set realistically and, second, enforced on schedule, future overcapacity will be reduced.
- Traditional pollution equipment manufacturers are typically not strong in research and development (R&D) and potential new entrants are in need of time and direction in their R&D. Federally-sponsored R&D is thereby essential to the development of future control technologies.

- Recognizing that a healthy abatement industry is clearly secondary to the primary purpose of environmental legislation (i.e., to control pollution), it is nonetheless less inflationary to consider the phasing of control programs with abatement industry capabilities. For example, from a supply standpoint, a policy which requires a mix of treatment activity across industries is preferable to one that requires one kind or level of treatment by all industries before moving on to another level.

Chapter I. INDUSTRY CHARACTERIZATION

A. MARKET DEFINITION

Our characterization of the pollution abatement equipment industry will be mainly in terms of major products and services and the companies which supply them. Where it is important, as in the demand analysis, we will give attention to customer-industry distinctions.

The air pollution control (APC) industry analyzed in this report is limited to the emissions from stationary sources. While mobile source emissions represented 54% of all air pollutant tonnage in 1970, the stationary sources served by the APC industry discussed herein accounted for 97% of the emissions of particulates and sulfur oxides.¹ With mobile source emissions omitted, the first line of distinction in the APC analysis will be between the particulate and gaseous control businesses.

The first dimension of division of the water pollution control (WPC) business is between its industrial and municipal segments. Although most of the products applicable to water pollution control may be used in both of these segments, the market structures associated with the industrial and municipal businesses differ so greatly as to require separate discussion throughout this report.

1. Product Markets

a. Air Pollution Control (APC)

A differentiation of the APC industry along the lines of the two major kinds of pollutants, particulates and gases, is appropriate because the technologies for their control are different. While particulate removal systems are primarily physical/mechanical technologies, gaseous control clearly requires more application of reaction chemistries. Accordingly, the companies which are becoming involved in the newer gaseous problem comprise a much different group than those concerned with the more traditional particulate problem. Although the traditional leaders in particulate control will continue to be involved in gaseous control efforts, they have already been joined by chemical companies, engineering firms, and other more general equipment suppliers.

The categories of APC products and related services which are given special attention in this report are listed in Table I-1. Within the particulate removal segment of the business, the demand analysis will distinguish between flange-to-flange sales of electrostatic precipitators, fabric filters (or bag houses), mechanical collectors, and wet scrubbers (or wet collectors). In gaseous emission control, the demand analysis will distinguish between the emerging SO₂ control systems (assumed to be scrubber-based) and the more traditional systems for gas or fume control (e.g., afterburners and adsorption systems).

¹*Environmental Quality* - The Third Annual Report of the Council on Environmental Quality, August 1972, p. 6.

TABLE I-1
MAJOR PRODUCT-MARKET CATEGORIES
IN AIR POLLUTION CONTROL

Particulate Removal Systems
Electrostatic Precipitators
Fabric Filters
Mechanical Collectors
Wet Scrubbers
Gaseous Control Systems
Wet Scrubbers
Afterburners, etc.
Associated Installation Services
Instrumentation

In addition to the specialty equipment categories, the APC business is also subdivided to include the other products and services categories listed in Table I-1. Associated installation services include those of design, assembly, erection, and auxiliary equipment systems. To the degree that much of these services are provided by equipment manufacturers and not by the general construction industry, a portion of that business is appropriate for consideration in this study. Instrumentation includes samplers, analyzers, monitors, and controllers for both ambient and stack systems.

b. Water Pollution Control (WPC)

The major WPC product categories emphasized in this report are listed in Table I-2. Equipment requirements are separated between specialty and non-specialty types. By specialty products are meant those which are produced largely for WPC applications. Thus, the most detailed product category is specialty equipment (from aerators to package treatment plants.) To that is added instrumentation and associated construction (e.g., accessory off-the-shelf equipment, pipe, cement, brick, and associated services provided by equipment manufacturers). Accessory equipment included in the associated construction category are those products which find their primary market in non-pollution applications. Instrumentation is reported as a separate category because the manufacturers represent a different group than that which supplies the larger hardware. Chemicals may be similarly divided between specialty and commodity categories and their associated services.

TABLE I-2
MAJOR PRODUCT-MARKET CATEGORIES
IN WATER POLLUTION CONTROL

Treatment Plant Proper
Specialty Equipment
Instrumentation
Associated Construction
Operating Materials
Specialty Chemicals

2. The Geographical Market

It is not critical to this study to consider either the air or water pollution equipment businesses along regional lines. In other analyses of the impact of pollution legislation upon customer-industries, it is imperative to be sensitive to the regionality of the paper industry, the smelting industry, etc. The APC and WPC businesses are as broadly-based as the industries and municipalities that they serve.

There are, as it turns out, distinct pockets of leading suppliers in certain parts of the nation, i.e., the New York-New Jersey area, Chicago, Philadelphia, Pittsburgh, Los Angeles, Baltimore, etc. However, this is a fair cross-section of industrial centers in the nation generally. The fabricators upon which the equipment systems manufacturers depend are typically regional or local shops, and, therefore, are also distributed according to the distribution of pollution customers.

The one exception, and an important one, to a lack of regionality in the air pollution control business will be created by the control of SO_2 emissions from coal-fired electric power plants. If (as has been assumed in this study) the bulk of the SO_2 control in coal-fired plants is handled by the stack gas cleaning route (as opposed to coal desulfurization or fuel switching), then a major locus of that business will develop along the "coal belt" roughly centered along the length of the Ohio River. This is not to say that equipment manufacturers will locate near that market, for the prospective entrants into that business are widely distributed across the country. It will mean, however, that the fabrication industries (in addition to general construction) in that area will be affected.

B. INDUSTRY STRUCTURE

1. Supplier Concentration

a. Air Pollution Control

The only existing industry structure in the APC industry which can be discussed in anything but qualitative terms is the lineup of companies which have served the traditional particulate control market. The flange-to-flange particulate control equipment business was estimated to be \$193 million in 1971 (See Chapter II). Many manufacturers of particulate control equipment also participate in the smaller gaseous control market of \$40 million (including both the emerging SO_2 scrubber systems and the more traditional fume control systems). In addition to this hardware market, the APC equipment companies also share in the business of services associated with the sale of the pollution control hardware. A rough rule-of-thumb in the industry is that the leading manufacturers participate in a business which is about twice the size of the hardware business. Therefore, the air pollution control business upon which concentration figures should be estimated is about twice the \$233 million hardware business, or \$466 million, in 1971.

An estimated ordering of leading APC equipment manufacturers by market share is reflected in the concentration analysis in Table I-3. The four firms believed to be the current volume leaders are Research-Cottrell, Joy Manufacturing, U.S. Filter, and American Air Filter. They are estimated to account for 35% of the total market. The next eight companies may not actually be in the order indicated but their combined market share is estimated to

Table I-3
CONCENTRATION ANALYSIS
AIR POLLUTION CONTROL EQUIPMENT

	% of Company Business In APC	Concentration Ratios (%)		
		Top 4	Top 12	Top 20
<u>TOP 4</u>				
Research-Cottrell	50-55			
Joy Manufacturing	10-15			
U. S. Filter	30-40	35	35	35
American Air Filter	25-30			
<u>NEXT 8</u>				
Wheelabrator-Frye	15-20			
Koppers	<5			
Boise-Cascade	<5			
Envirotech	10-15			
Peabody-Galion	10-15		25	25
Carborundum	<5			
Combustion Engineering	<5			
Universal Oil Products	<5			
<u>NEXT 8</u>				
Zurn Industries	5-10			
American Standard	<5			
Buffalo Forge	15-20			
General American Trans. Co.	<5			
Babcock & Wilcox	<5			10
Combustion Equipment Assoc.	30-40			
WW Sly	60-70			
Hart-Carter	30-40			
	TOTAL	35	60	70

SOURCE: Arthur D. Little, Inc.

account for another 25%. The last eight companies of the top 20 may again be aligned somewhat different but are believed to account for another 10%. Thus, out of more than 300 companies which participate in the APC business, the leading 12 companies account for 60% of the total market and the leading 20 companies account for 70%. These estimated concentration ratios are similar to ones available from the 1967 Census of Manufacturers for the closest five-digit SIC category (SIC No. 35642 Dust Collection, etc.). The total sales for that SIC category were about twice that of air pollution control sales in 1967 and clearly represents a broader industry. The concentration ratios for that five-digit industry were 35%, 49%, and 73% for the top four, top twelve, and top 20 companies respectively.

A concentration ratio of 40% or less for the largest four companies in an industry is usually considered conducive to effective competition.² Since that general guideline is applicable at the four-digit SIC industry level, the 35% concentration ratio of the top four firms in the APC industry (which is more specific than a five-digit industry) is not cause for concern. By comparison, the top four firms in the larger but pollution-related businesses of steel power boilers, etc. (SIC No. 34433) and steam engines and turbines (SIC No. 3511) accounted for more than 75% of their businesses in 1967.

There has been a trend towards increased concentration of the APC business in recent years, but the exact amount would be hard to quantify. There have been a few mergers which have combined more than one manufacturer into a larger industry participant. These include U.S. Filter's acquisition of Ducon and Slick and Zurn's acquisition of Clarage Fan and Fly Ash Arrestor. A second cause of increased concentration has derived from the above average growth of electrostatic precipitators. The bulk of electrostatic precipitators are supplied by a few manufacturers, i.e., Research-Cottrell, Joy Manufacturing, Koppers, and Envirotech. In the 1970's, as electrostatic precipitators begin to slow in its penetration of the total particulate control market and as SO₂ control systems begin to represent a greater portion of the total equipment business, the concentration in the air pollution control business should level off and may even decline.

The leading APC manufacturers tend to sell a broad product line of equipment. As indicated in Table I-4, fourteen of the twenty companies listed are capable of supplying four of the five major product categories. The top four firms supply all five types of equipment.

b. Water Pollution Control

The water pollution control industry is usually viewed in terms of the broader business of both water and wastewater treatment. As the products used in the treatment of effluent waters are similar to those used in the treatment of influent waters, the leading WPC equipment companies have been traditionally strong in water treatment. Although the demand analysis in this report will focus on the water pollution portion of the total, this discussion of industry structure will relate to the broader business of water and wastewater treatment.

The relevant market upon which to make a market share analysis is that of specialty equipment for both water and wastewater treatment. To a market of \$275 million in wastewater treatment equipment in 1971 (See Chapter II) would be added, therefore, nearly

²Cf. J. S. Bain, *Barriers to New Competition*, Harvard University Press, 1965, p. 218.

TABLE I-4

PRODUCT LINE COVERAGE OF
LEADING SUPPLIERS OF AIR POLLUTION CONTROL EQUIPMENT

<u>Company</u>	<u>Electrostatic Precipitators</u>	<u>Fabric Filters</u>	<u>Mechanical Collectors</u>	<u>Wet Scrubbers</u>	<u>Afterburners Adsorbers, Etc.</u>
Research-Cottrell	X	X	X	X	X
Joy Manufacturing	X	X	X	X	X
U.S. Filter	X	X	X	X	X
American Air Filter	X	X	X	X	X
Wheelabrator-Frye	X	X	X	X	
Koppers	X			X	
Boise Cascade	X			X	
Envirotech	X	X	X	X	X
Peabody-Gallion		X	X	X	X
Carborundum	X	X	X	X	X
Combustion Engineering					
Universal Oil Products	X	X	X	X	X
Zurn Industries		X	X	X	X
American Standard	X	X	X	X	X
Buffalo Forge		X	X	X	X
Gen'l Amer. Trans.		X	X	X	
Babcock & Wilcox				X	
Combustion Equip. Assoc.		X	X	X	X
W. W. Sly		X	X	X	X
Hart-Carter		X	X	X	

\$200 million in water treatment equipment. This estimated total market in 1971 of \$475 million relates only to the hardware market and not to the associated services and products supplied by the specialty equipment manufacturers. These associated services are much less a part of the WPC equipment business than is true of the APC business.

In Table I-5 the four volume leaders – Envirotech, Ecodyne, FMC, and Dorr-Oliver – are indicated to hold about 20% of the relevant market. Although the order and membership of the next eight companies may not be accurate, this or a similar group are estimated to hold another 25% of the market. Finally, the last eight of the top twenty firms as illustrated by the ones listed in Table I-5 should account for another 15% of the market. By the same 40% standard of concentration in the top four firms noted in the APC analysis, there is no undue amount of concentration apparent in Table I-5.

These concentration estimates compare with the closest five-digit SIC industry category (SIC No. 35892, Service Industry Machine and Parts, including water treatment equipment) in which the total 1967 sales were roughly twice that of the water (influent) treatment business at that time. Then, the Census of Manufacturers indicated concentration ratios of 20, 33, and 54% for the top four, twelve, and twenty firms. Thus, of the more than 400 firms which participate in the larger water and wastewater treatment business, the top twelve accounts for about 45% of the market and the top twenty for about 60% of the market.

Although the amount cannot be quantified meaningfully, there has been significant consolidation of the WPC equipment industry in recent years through mergers. Notable examples are: the merging of EIMCO and Bartlett-Snow-Pacific into Envirotech; FMC's acquisition of both Link-Belt and Chicago Pump; the combination of Wallace & Tiernan and Sharples within Pennwalt; and Neptune Meter's acquisition of Micro-Floc and Nichols Engineering.

The product line coverage of major WPC equipment categories for the twenty companies is presented in Table I-6. Six of the twenty companies provide eight or more of the ten product areas listed. These six companies include the top four plus Rex Chainbelt and Westinghouse. In a Department of Commerce survey³ of equipment shipments in 1970, more than half of the companies were one product firms. Another fourth only supplied two or three of the relevant products. In that same survey, the largest 25 firms accounted for just over 60% of the total shipments. Similarly, in 1968, the largest twelve firms accounted for 37.5% of the total shipments. These compare favorably with the concentration estimates above.

2. Marketing Practices

In the industrial markets of both air and water pollution control, the predominant marketing relationship is a direct one between the manufacturer and the industrial customer. For the larger national companies, these sales are handled by their own sales forces. In less important product lines and for the regionally-based suppliers, sales are handled by manufacturers' representatives and local distributors.

³Kollar, K.L. and Youngwirth, W.G., "The Market for Water and Wastewater Equipment", *Construction Review*, October/November 1971, U.S. Department of Commerce, pp. 1-9.

TABLE I-5
CONCENTRATION ANALYSIS
WATER/WASTE TREATMENT EQUIPMENT

	% of Company Business In <u>W/WT</u>	<u>Concentration Ratios (%)</u>		
		<u>Top 4</u>	<u>Top 12</u>	<u>Top 20</u>
<u>TOP 4</u>				
Envirotech	25-30			
Ecodyne	25-30	20	20	20
FMC	<5			
Dorr-Oliver	20-25			
<u>NEXT 8</u>				
Pennwalt	5-10			
Rex Chainbelt	5-10			
Sybron	5-10			
Crane	<5		25	25
Westinghouse	<5			
Neptune Meter	25-30			
Peabody-Galion	15-20			
Sunbeam	<5			
<u>NEXT 8</u>				
Dravo	<5			
Chicago Bridge & Iron	<5			
Davis Industries	40-50			
Clow	10-15			
Bird & Sons	5-10			15
Beloit-Passavant	80-90			
Komline-Sanderson	50-60			
Roberts Filter	10-20			
	TOTAL	20	45	60

SOURCE: Arthur D. Little, Inc.

TABLE I-6
PRODUCT LINE COVERAGE OF LEADING SUPPLIERS OF
WATER AND WASTEWATER TREATMENT EQUIPMENT

Company	Aerators And Mixers	Chlorinators And Chemical Feeders	Degritters And Screens	Deaerators And Filters	Digestors	Flotation Equipment	Ion Exchange Units	Treatment Plants	Pumps And Pumping Stations	Sedimentation And Clarification
Envirotech	X	X	X	X	X	X			X	X
Ecodyne	X	X	X	X	X	X		X	X	X
FMC	X	X	X	X	X	X		X	X	X
Dorr-Oliver	X		X	X	X	X		X	X	X
Fennel	X	X	X	X	X	X		X	X	X
Rex Chainbelt	X	X	X	X	X	X		X	X	X
Sybron	X		X	X	X	X		X	X	X
Crane										
Westinghouse	X	X	X	X	X	X		X	X	X
Neptune Meter	X		X	X	X	X		X	X	X
Peabody-Gallion	X		X	X	X	X		X	X	X
Sunbeam										
Dravo	X			X	X	X				
Chicago Bridge & Iron	X		X	X	X	X		X	X	X
Davis Industries	X		X	X	X	X		X	X	X
Clow	X	X								
Bird & Sons	X			X	X	X		X	X	X
Beloit-Passavant	X			X	X	X		X	X	X
Konline-Sanderson	X			X	X	X		X	X	X
Roberts Filter										

a. Municipal Marketing

The most distinctive marketing structure in this country's pollution control business is found in municipal sewage treatment (and to a lesser degree, air pollution control of municipal incinerators). There, the major contact of the company's salesman or agent is with the consulting engineering firm. The consulting engineer represents the interests of the customer, the source of design, and the source of product specification for municipal sewerage facilities. It is to the consulting engineering which the original equipment manufacturer must sell – not the ultimate customer. The situation is somewhat different for the suppliers of operating and replacement items such as specialty chemicals where the manufacturers have reason to deal directly with municipal plant operators and authorities.

The marketing structure in the municipal market also extends to governmental bodies involved in the approval of treatment systems. Before the environmental era, these parties were primarily local and state health authorities. The consulting engineering firms, in their turn, have traditionally been required to "sell" these authorities (i.e., keep in touch with their requirements). This "following through" on plant designs is clearly one of the services the consulting engineers provide to their municipal clients. Of late, this marketing structure has extended to include review by EPA – particularly where federal grant monies are involved.

This 5- or 6-layered structure (manufacturer/distributor/consulting engineer/municipality/local authorities/EPA) takes its toll not only in efficiency but also in time and technological content. To the extent that traditional technology continues to be used and to the extent that consulting engineering firms and municipalities freely draw on manufacturer services, manufacturing profit margins will remain low under this marketing system.

Manufacturers are interested in promoting new products which will better demand proprietary margins. Consulting engineering firms, while interested in providing a better product, are more influenced by the need to protect continuing relationships with municipal clients; they have seen all too many examples of half-baked technologies and inoperable systems. For these reasons and to minimize their risks, the consulting engineering firms are strongly wed to a conservative attitude.

The position of municipalities, as well, is conducive to a conservative attitude towards new technology. A municipal administration risks enough by adding new municipal facilities to the existing tax base without having that investment backfire in form of a system that doesn't work.

Traditionally, the local and state health authorities represent a third major source of conservative attitude in this market system. As with the consulting engineers and the municipal administrators, their jobs are made easier if the safest and surest solution is chosen.

EPA's entry into this structure has, for the most part, been on the side of progressive technology. While EPA has added another layer to this burdensome system, its presence does lend support to the major source of progressive pressures heretofore – the manufacturer.

b. Purchasing Factors

Based on discussions with equipment manufacturers, there are five major reasons behind

customer investments in pollution control facilities. *Foremost among these is the growing enforcement of state and federal statutes.* In many cases, the customer simply has his back against the wall and cannot play the waiting game that has delayed the growth of the pollution control business generally.

The second most common reason is associated with the first. It is the realistic planning of some customers to invest in pollution control systems either for new plants or where it is clear that enforcement is imminent. A third reason is a traditional one for pollution control activity – good housekeeping practice. A fourth reason, good citizenship, is not a widespread motivation across industry, but it lends an occasional assist. Finally, in insulated situations, the anticipated process savings (or credits against the costs) from pollution control is involved in the decision.

When the customer has decided to invest for any of the reasons above, the considerations which then affect his choice of equipment and suppliers differ between markets. In air pollution control, current purchase decisions are about equally influenced by price and performance. In the industrial purchase of wastewater treatment equipment, product quality would appear to be most important, followed by price and supplier reputation.

In municipal markets, however, price continues to be the leading purchase determinant, followed by supplier reputation and product quality. This ranking of municipal purchase considerations places some interesting conditions upon new entry into that market. Since price is the most important factor, it suggests that new entrants can use that time-honored weapon upon which to build a market position. On the other hand, the ranking of supplier reputation over product quality means that present suppliers are well entrenched.

c. Reluctant Customers

An industrial salesman can usually depend upon customer satisfaction for selling leverage. One important aspect of this satisfaction usually lies in the customer being able to use a product to enhance his own product, productivity, and profits. Much of this customer satisfaction, however, is denied to pollution equipment salesmen and to pollution control equipment companies. Their customers are basically reluctant ones – reluctant because these purchases are costs without positive contribution to profits.

Given this abnormal supplier/customer relationship, we have compared it to some of the relationships in other professions and businesses. The pollution control equipment supplier, on the one hand, would like to be viewed as the doctor who is called upon to solve a customer's problems. However, most of the business in today's pollution market is better likened to the lawyer/client relationship. The lawyer is here viewed as the refuge of parties in trouble. The lawyer's expertise like that of the equipment supplier is respected, but the reasons for the relationship in the first place are generally negative for the legal client as well as the pollution control equipment customer.

Because pollution equipment companies are businesses and not law firms, they cannot be satisfied with the lawyer's posture of waiting for the business to come to him. Equipment suppliers, in this case more than like an insurance salesman, must aggressively sell their products to potential customers, even though the product only reminds customers of their problems. In this manner, the pollution business of 1972 is characterized as selling a negative product (like insurance companies) to customers who are most influenced by having their backs against the wall (in the manner of legal clients).

d. Purchasing Delays

Depending on the size and type of installation, the delay between the decision to invest in pollution control equipment and the final purchase and operation of that equipment lies between eight months and three years in air pollution control. For the smaller and less sophisticated installations, the timing is usually 8-15 months while for the larger (e.g., power plants) the delay can be 2-3 years. In the case of power plants, this delay is usually about two years for a grass roots plant and closer to three years for a backfitted plant.

In water pollution, the delays are more correlated to whether it is a municipal or industrial market. In industrial markets, the delay is in the order of 1-2 years. In municipal markets, the delay from the point of decision to final operation is more like 3-5 years. This extended delay in municipal facility construction is broken down as follows. Historically, about 1.5-2 years is consumed from the time of the appointment of the consulting engineering firm to the setting of final design and specification requirements. Now, with the increased requirements for solicitation of federal funds, this time has expanded to 2-3 years. From the time of design specification to the awarding of the contract, it usually takes 3-6 months. From the awarding of the contract to the beginning of construction takes 0-3 months. Final construction and operation of the municipal plant takes another 18 months. Deliveries of major equipment items can usually be made within 3-6 months from the time of order.

3. Foreign Markets and Competition

The material necessary for an analysis of demand for pollution abatement equipment in the major countries of the world is available. However, the value of a detailed analysis for this study is questionable. The material which was covered may be divided into two areas: a) discussions of pollution abatement developments in selected major countries and b) discussions of specific markets in Western Europe.

For the analyses of individual countries, we have focused on those which are leading the way in pollution abatement legislation and implementation. We have attempted only to summarize the significant features of anti-pollution legislation in those countries. The discussion of international trends focuses upon supra-national organizations and their effects upon member nations. The final statistical analysis touches upon Western European countries as a unit and is geared toward projections of their import (U.S. export) markets for pollution abatement equipment. Only a limited analysis has been made of what part of this latter market shall be open to U.S. export competition.

a. Discussions of Selected Countries

The date of the latest information we utilized from the Department of Commerce is noted in parentheses. Canada was not included in the analysis.

Austria (4/70). Austria is well industrialized and, as with most European countries, has stressed water quality standards above air quality standards. However, both air and water quality standards lag behind the U.S. The federal government has no air quality standards except for industrial codes and building regulations. These codes and regulations detail specific permissible fuel-oil sulfur contents, smoke and particulate emissions, and stack

heights. Most action on the air quality front arises from the protection of public health. Over the 1970-1980 decade, both air quality and water quality legislation are expected to be strengthened.

Belgium (8/69). Belgium is densely populated and heavily industrialized. There were a few air pollution incidents in 1969 leading to pressure for tighter controls. Several air quality laws enacted in the 1960's contain only broad provisions. Water quality has been more important, as reflected in more strict legislation and the plans of the Belgium government to subsidize the construction of municipal sewerage facilities.

France (5/70). France has a relatively low density population for Europe but is heavily industrialized. France has rather comprehensive pollution laws and supports pan-European development of air emission controls as proposed by the Economic Commission for Europe. Auto emission standards have already been established, and France intends to fully adopt the pan-European auto emission standards scheduled for implementation in late 1972. France likewise has comprehensive water quality legislation on the books. Legislation empowers the federal government to monitor water quality and local governments to punish offenders.

West Germany (12/69). West Germany is a highly industrialized country with a dense population. Thus, pollution is a problem, and concern is widespread. German environmental quality laws, on the whole, are the most advanced in Europe, and its markets for pollution abatement equipment is the largest of the international markets.

The responsibilities for air quality control are scattered between federal and local governments. There are no regulations safeguarding public health specifically. The federal government has had a legislative basis for controlling industrial emissions since 1960. Under the law, an operating license must be applied for by all industries. If the pollution levels of an industry are too high, the operating license is not granted. To qualify for a license, new plants must have had the latest air pollution abatement equipment installed. West Germany has had strict vehicle emissions standards since 1968. These vehicle emissions standards conform with those proposed by the Economic Commission for Europe.

Likewise, West Germany has had the most advanced legislation and implementation schedules for water and wastewater treatment. West Germany also has the most advanced European technology in pollution abatement equipment and, hence, is a prime foreign competitor in the U.S. market.

Great Britain (6/70). Britain's dense population and industry contribute to a major pollution problem. Air quality legislation has been passed in several forms which regulates emissions from practically all polluting industries; that which requires proper air quality equipment in new buildings; and that which limits smoke and vapor emissions from motor vehicles. It appears that stronger vehicle emissions standards shall be passed in the future, conforming with the pan-European standards of the Economic Commission of Europe. There has been a general increase in pressures for better air quality with the establishment of the Natural Environment Research Council. So far, however, enforcement has been slow.

Italy (2/70). Italy is less industrialized than some of its European counterparts which diminishes the pressures for pollution control and the demand for pollution abatement equipment. Air pollution has drawn some attention. The citizenry seems most intent upon halting the air pollution by industrial works, power plants, and refineries but less concerned about vehicular pollution.

Japan (8/69). Japan has been paying a price for economic growth over the post-war period. The small island nation is densely populated, densely industrialized, and densely polluted. Over the past decade alone, heavy and chemical industries have grown six times, light industry production has tripled, and the use of passenger cars has increased by 1500%. Thus, both air and water pollution problems are demanding immediate attention.

Federal water and air pollution legislation and research are comprehensive. As such, Japan presents a fertile market for pollution abatement equipment. However, Japanese industry shall be supplying much of that demand as well as competing internationally with U.S. exports of such equipment. Given the severity of the pollution problem, Japan will represent a relatively large market for pollution abatement equipment over the coming decade. How much of this market the U.S. can serve needs further investigation.

Summary. This discussion of specific countries is intended to be representative rather than comprehensive. It is clear that all developed nations are beginning to come to grips with pollution. Depending upon the severity of their pollution, upon the industrial and demographic characteristics of their countries, and upon their legislative response and citizen concern, different countries are tackling the problem in different tempos. Japan, West Germany, the Netherlands, and France have responded more quickly to their greater pollution problems. Italy has the slowest response. The responses of Belgium and Switzerland lie somewhere in the middle. The chief European concern has been water pollution and relatively speaking, adequate air pollution legislation has been lacking. Thus, any substantial European demand for U.S. pollution abatement equipment has been (and shall be over the next several years) centered in water pollution abatement equipment.

b. European Market Analysis

The need for concerted international action is particularly strong in environmental problems. Toward this end, various supra-national activities have risen to coordinate research, implementation, and enforcement of environmental quality measures. Several European examples include the work of Eurotom, the Economic Commission for Europe, and the OECD. Eurotom recognized the regional nature for European water pollution early in the 1960's. In 1963, Eurotom set up 600 sampling stations on the Rhine. The Economic Commission for Europe, an agency of the EEC, is empowered to set automotive emission standards for the EEC and to supervise other environmental research. The Organization for Economic Cooperation and Development (OECD) has set up various ad hoc groups to study different air and water pollution problems.

Given this brief discussion of the national and supra-national impetus for pollution abatement, we have reviewed the consequential markets for the equipment. The discussion below focuses first upon selected countries of Western Europe: France, Belgium, Germany,

Italy, the Netherlands, and Switzerland. The figures are based upon a Department of Commerce study.⁴ The second discussion focuses upon a wider range of nations and attempts to isolate the current major export markets for U.S. pollution abatement equipment.

The discussion of legislation in different countries above revealed a growing concern about pollution, hence a growing demand for pollution abatement equipment. U. S. legislation on the whole has come earlier and has been more comprehensive. While U. S. pollution equipment producers have had that edge on European competitors, many countries are protecting their pollution abatement equipment industries.

In Europe, France and Germany are the major competitors of U.S. equipment. Japan does not seem to be a big competitor in Europe. The possible import markets in the Western European countries have been quite small in comparison to the total markets in each of the countries. For example, the estimated dollar value of imports of water purifying equipment by country in 1969 are given in Table I-7.

TABLE I-7
DOLLAR VALUE OF IMPORTS FOR WATER PURIFYING EQUIPMENT IN 1969

	<u>Millions of \$</u>
France	7.256
Belgium	3.032
Germany	2.065
Italy	1.700
Netherlands	2.300
Switzerland	0.425

The estimates include equipment for purifying potable and industrial water as well as treating wastewater. France and Germany are fierce competitors in this area. Lurgi of Germany, Degremont of France, and Phillips of the Netherlands are all continentally- and internationally-recognized leaders in the pollution abatement field. The long shipping distance from the U.S. also gives European firms further protection from the importation of fabricated goods, leaving U. S. Participation primarily through European-based affiliates.

As stated above, Europeans have been more concerned with water and wastewater treatment equipment facilities. Thus, the total import markets for air pollution abatement equipment are much smaller than those for water pollution abatement equipment. This can be seen by comparing Table I-7 with Table I-8. Table I-8 lists U.S. Department of Commerce estimates of the *total* markets for air pollution control equipment in the major European countries. The import market would be much smaller. These estimates, however, do not include the power generation industry.

⁴*Markets for Pollution Control Equipment in Europe, Comprehensive Summary*, U.S. Department of Commerce, Bureau of International Commerce, DIB 71-03-507, August 1970.

TABLE I-8
AIR POLLUTION CONTROL EQUIPMENT MARKETS IN 1969

	<u>Millions of \$</u>
France	55
Northern Italy	15
Netherlands	10
Belgium	8
Switzerland	<u>5</u>
	93

Table I-9 gives an indication of the actual size of the import markets for two specific types of air pollution control equipment: analysis instruments for gas and smoke and equipment for gas filtering and purifying. Notice that U.S. exports constituted 17.4% of these import markets in analysis instruments and 13.2% of the markets of gas filtering equipment. It should be noticed that U.S. exports to these countries in 1969 totalled only \$.3 million for analysis instruments for gas and smoke and \$2.2 million for gas filtering and purifying equipment. Both are quite small – in both cases, less than 2% of the U.S. market. The small import market can be explained by several factors: 1) a lack of strong air quality legislation; 2) a strong European industry in France and Germany; and 3) unfavorable transportation economics.

TABLE I-9
U.S. SHARE OF THE EUROPEAN AIR POLLUTION
CONTROL EQUIPMENT IMPORT MARKET IN 1969

<u>Country</u>	<u>Total Imports</u>		<u>Imports from the U.S.</u>	
	<u>Equipment</u>		<u>Equipment</u>	
	<u>Analysis</u> <u>Instruments</u> <u>\$1000</u>	<u>for Gas</u> <u>Filtering</u> <u>\$1000</u>	<u>Analysis</u> <u>Instruments</u> <u>\$1000</u>	<u>for Gas</u> <u>Filtering</u> <u>\$1000</u>
France	728	5,341	116	760
Italy	444	4,270	56	889
Belgium	464	1,896	128	292
Netherlands	234	4,341	26	162
Switzerland	—	627	—	64
	<u>1,870</u>	<u>16,460</u>	<u>326</u>	<u>2,167</u>
% U.S. Share of Total	—	—	17.4%	13.2%

Source: EEC Figures.

Table I-10 lists the municipal waste treatment markets in Europe and Table I-11 indicates the import markets for water treatment equipment in each country and the U.S. share of the market. In Table I-11, the U.S. accounted for 39.6% of all imports to the six countries listed. This amount, or about \$6 million was about 2% of the U.S. market for specialty equipment in 1969.

4. Relation to the Business Cycle

The cyclical movements of the economy would be expected to influence the aggregate purchase of pollution abatement equipment for several reasons. Capital investment is stimulated by the availability of internal funds. It is linked to the levels and changes in output in accelerator fashion: greater fixed capital investment spending is stimulated during upturns in the cycle. Neoclassical theories of investment link investment spending to cyclical costs of capital. Thus, in forecasting future investment in pollution abatement equipment, at least some attention must be directed toward macroeconomic forecasts of the business cycle.

Such macroeconomic influences must, of course, be tempered by other considerations in our analysis. One such factor is that expectations affect pollution abatement expenditures. For example, over the cycle from 1967 to 1972, the demand for water pollution abatement equipment was rather constant. Both industries and municipalities have shown a history of postponing implementation of pollution control plans until forced to comply. As a result, pollution investment has been, and is expected to remain, rather inelastic to the business cycle.

A second factor is that, without rigorous enforcement, demand for pollution abatement equipment is of a residual nature. It is of least importance to the production needs of an industry. Thus, although increased fixed capital investment in production equipment is certainly directly *induced* by a cyclical upturn, investment in pollution abatement equipment alone may only be *facilitated* by such an upturn.

On the other hand, federal and state authorities are applying increased pressure, and both industries and municipalities realize that the air and water standards are being taken seriously. Under these circumstances, pollution control is becoming accepted almost as a necessary "license to operate". Hence, investment in pollution equipment shall probably be more sensitive to general economic conditions in the future, as it becomes an integral part of expansion.

The actions of large companies has given another indication that pollution abatement investment won't be entirely inelastic over time to cyclical cash flow considerations. In general, large companies with better cash flow positions have been more responsive to water and air quality compliance schedules. Hence, we may generalize that an upturn and consequently improved cash flow positions shall increase the ability of these firms to purchase equipment.

In any case, a brief forecast of relevant macroeconomic variables is charted in Table I-12 below. These forecasts are culled from the ADL Input-Output Model. The ADL Input-Output Model incorporates the latest techniques in input-output analysis into a tool for macroeconomic and industrial forecasts. It includes 203 sectors and is used to make

TABLE I-10

ANTICIPATED AVERAGE YEARLY EXPENDITURES ON EQUIPMENT
FOR MUNICIPAL SEWAGE TREATMENT IN EUROPE

	<u>Million \$ Per Year</u>
Germany	60
France	35
Switzerland	12
Netherlands	9 - 10
Northern Italy	5 - 7
Belgium	<u>1 - 2</u>
	122 - 126

SOURCE: EEC Figures.

TABLE I-11

U.S. SHARE OF THE EUROPEAN WATER TREATMENT
EQUIPMENT IMPORT MARKET IN 1969

	<u>Imports, Thousands \$</u>	
<u>Country</u>	<u>Total</u>	<u>From the U.S.</u>
France	7,256	3,920
Belgium	3,032	1,320
Germany	2,065	524
Italy	1,747	171
Netherlands	1,309	148
Switzerland	<u>425</u>	<u>--</u>
	15,834	6,083
% U.S. Share of Total		39.6%

SOURCE: EEC Figures.

short-term and long-term national and industrial forecasts. The shorter term forecasts (1972-1974) are quite sensitive to cyclical changes in the economy while the longer term forecasts (beyond 1974) begin to show less of an influence of the business cycle as the economy settles into gradual longer-term trends.

These predictions assume that the wage/price controls are moderately successful; that trade statistics do not show a marked improvement; that collective bargaining contracts of 1973 and the inabilities of the Price Commission to regulate particular consumer commodities may refuel inflationary pressures; and that business investment slows somewhat. If business and consumer confidence should sag more than moderately, these forecasts would be revised downward.⁵

Table I-12 and Fig. I-1 chart the forecasted macroeconomic trends throughout the decade. In general, the growth rates of GNP, consumption, and government spending peak in 1972 and could continue near that level into 1973. Thereafter, a downturn is forecast in the growth of GNP, consumption, and government spending due to the assumptions mentioned above. 1974 through 1976 reveal a more moderate yet more enduring expansion than the preceding 1971-1972 recovery. This is followed by slower growth throughout the remainder of the decade.

The trends in investment show a large increase throughout 1972. Business spending on capital equipment is expected to increase 11-12% over 1971. Such spending is and will continue to be stimulated by rising business confidence in addition to such economic motivations as higher profit margins, increased tax credits, and liberalized depreciation allowances. Thus, the response to generally good economic conditions has been a large investment spurt in structures and durable equipment. The spurt in structures is expected to be curtailed by the rise in interest rates already discernable.

This rapid growth over 1971 in both construction and the purchase of producers' durable equipment as a whole has not been fully matched by a spurt in the investment in pollution abatement equipment. One reason for this inelasticity in the purchase of pollution abatement equipment to the 1972 mini-boom has been that the liberalized depreciation allowances have been extended to all production equipment rather than pollution abatement equipment alone, as had previously been the case. Table I-12 reveals the downturn in construction expected: non-residential structures growth drops to 5.0% over (72-73) from 6.7% over (71-72). Gross Private Domestic Investment falls in Figure I-1 and cycles around 4.0% for the rest of the decade.

Although investment in pollution abatement equipment has not yet spurted as a result of the 1972 expansion, the ADL forecasts do indicate steady general investment demand through the 1970's which should *facilitate* pollution control spending as needed. It should be observed that the investment in producers' durable equipment cycles about 5.2%. At this rate, investment in producers' durable equipment grows at a pace above the growth rate of GNP, personal consumption, and gross private domestic investment. Thus, the growth of investment in producers' durable equipment continues at a comparatively high level through 1978 when it finally falls to about 5.0%. This provides a climate in which the demand for

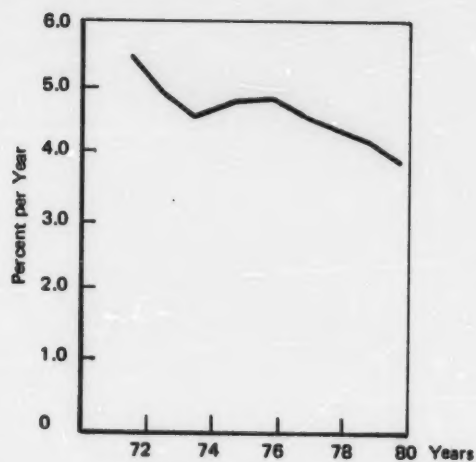
⁵The full input-output analysis includes two other possible scenarios — a scenario of high success and one of poor performance.

TABLE I-12

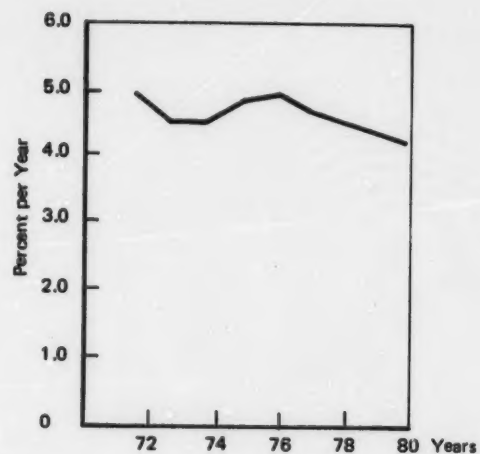
MACROECONOMIC FORECASTS FOR 1971-1980

	Billions of Constant 1958 Dollars									
	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
Gross National Product - Total	739.4	780.4	818.6	856.4	897.3	941.2	985.2	1029.3	1074.0	1117.2
Personal Consumption Expenditures	491.8	515.2	538.5	512.5	589.3	618.4	647.4	676.5	705.7	735.3
Gross Private Domestic Investment	108.5	118.5	123.4	128.4	133.5	138.7	144.0	149.5	155.3	161.2
Non Residential	79.3	84.6	88.8		97.7					122.2
Structures	22.4	23.6	24.5		26.4					30.6
Producers Durable	56.9	61.0	64.3	67.7	71.3	75.0	78.9	83.0	87.2	91.6
Residential	27.0	28.2	28.6		30.0					33.7
Change in Inventories	2.1	5.3	6.0	5.9	5.8	5.7	5.5	5.4	5.4	5.3
Exports	52.1	52.5	56.2	59.6	63.3	67.2	71.2	75.4	79.9	84.6
Imports	52.2	51.9	52.4	54.6	57.5	60.6	63.8	67.8	72.3	77.1
Government - Total	139.2	146.5	152.9	160.5	168.1	176.9	185.5	194.4	203.6	213.2
Federal Government	62.2	65.2	67.9		74.3					93.2
Defense	45.5	46.3	47.0		49.5					59.1
Non Defense	16.7	18.9	20.9		24.8					34.1
State & Local	77.0	81.3	85.0		94.2					120.0

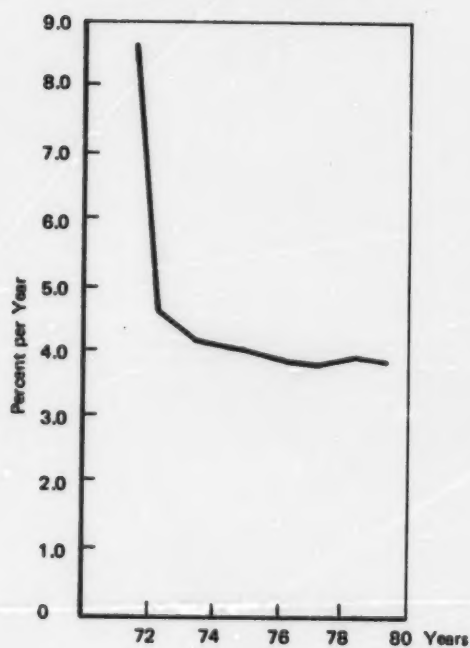
Sources: Growth Patterns of U. S. Industries and Markets in 1973: The Year Ahead, Arthur D. Little, Inc., June 1972 Growth Patterns of U. S. Industries in the Seventies, Arthur D. Little, Inc., June 1972.



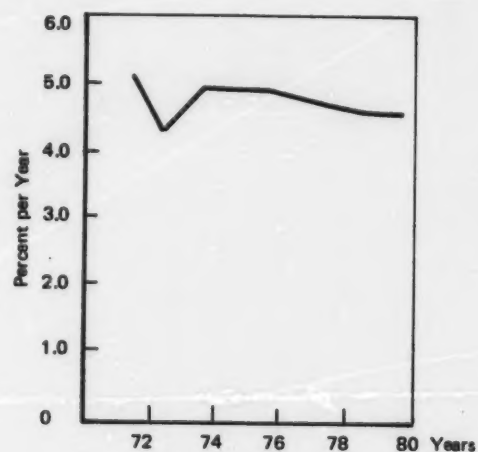
A) GROSS NATIONAL PRODUCT



B) CONSUMPTION



C) INVESTMENT



D) GOVERNMENT SPENDING

Source: Arthur D. Little, Inc. estimates.

FIGURE I-1 PERCENTAGE GROWTH IN GNP AND SELECTED COMPONENTS (In real terms)

pollution equipment may achieve a higher level than that usually necessary for normal replacement and expansion investment.

C. INDUSTRY PERFORMANCE

1. Classification of Companies

Table I-13 lists the selected companies which were utilized in the analysis of industry performance. A more complete list of pollution control companies appears in Appendix A (Table A-1). The companies were divided broadly into two groups: the "in" companies for which pollution control is a *major* part (e.g., 5% or more of sales) of their total business, and the peripheral or "near" companies for which pollution control is a *minor* part (much less than 5% of sales) of their total business.

"In" and "near" companies were selected in each of the pollution abatement industries. The resulting groupings include: Air Pollution Equipment – Particulate Control; Air Pollution Equipment – Gaseous Control; Water Pollution Control Specialty Equipment; Air and Water Pollution Control Instrumentation Equipment; and Water Pollution Control – Specialty Chemicals.

2. Sales and Earnings Growth of "In" Companies

For selected "in" companies, the growth rates for the past nine years and the most recent five years in sales and earnings after taxes are presented in Table I-14. In most cases the sales growth rates have been excellent, showing on the average more than a 10% compound annual growth rate per year. Earnings have performed well also, although they have not grown as fast as sales.

In the Air Pollution – Particulate Control group there are a number of companies including Envirotech, Peabody-Galion, Research-Cottrell, and Zurn, which are heavily committed to the broader (air-water-solids) pollution control businesses. The high (over 35%/year) growth rates over the last five years in sales reflect the active acquisition programs of these companies.

Compared to the Air Pollution Equipment group, the Water Pollution Equipment group (except for Envirotech) has not shown as rapid sales or earnings increases. Also, the recent five-year average annual sales growth rate has been lower than the average for the past nine years. Profits have declined in a similar fashion.

The instrumentation companies experienced a difficult time both with sales and earnings, particularly in the last five years. In nearly all of the cases the sales and earnings compound annual growth rate for the most recent five years has been lower than the compound annual growth rate for the past nine years.

The Water Pollution Control Specialty Chemicals group includes three representative chemical manufacturers. Although the nine-year growth rate is presented for only one company (Nalco), it is thought that this growth rate is typical for the companies in this industry. Sales and earnings growth in the most recent five years are not quite as rapid as the growth rate for the past nine years. Compared to the other companies in the pollution

TABLE I-13

CLASSIFICATION OF LEADING POLLUTION CONTROL COMPANIES USED
IN FINANCIAL COMPARISONS¹

I. Air Pollution Equipment - Particulate Control

<u>As Major Part of Business Now ("IN")</u>	<u>As Peripheral to Main Business ("NEAR")</u>
American Air Filter	American Standard
Buffalo Forge	Boise Cascade (Chemico)
Carborundum (Pangborn)	Combustion Engineering
Combustion Equipment Associates	Foster Wheeler (Belco)
Envirotech (Buell)	General American Transportation (Fuller)
Joy Mfg. (Western Precipitation)	Koppers
Peabody-Galion	
Research-Cottrell	
W. W. Sly	
Universal Oil Products	
U. S. Filter (Slick, Ducon)	
Wheelabrator-Frye	
Zurn	

II. Air Pollution Equipment - Gaseous Control

<u>As Major Part of Business Now ("IN")</u>	<u>As Peripheral to Main Business ("NEAR")</u>
- None -	Babcock & Wilcox
	Boise Cascade (Chemico)
	Combustion Engineering
	Combustion Equipment Associates
	Foster Wheeler
	Midland-Ross
	Monsanto
	Peabody-Galion
	Research-Cottrell
	Sunbeam (John Zink)
	Universal Oil Products
	Wellman Power Gas
	Zurn

¹ For more complete list of companies see Appendix A, Table A-1.

TABLE I-13 (continued)

CLASSIFICATION OF LEADING POLLUTION
CONTROL COMPANIES USED IN FINANCIAL COMPARISONS

III. Water Pollution Specialty Equipment

<u>As Major Part of Business Now ("IN")</u>	<u>As Peripheral to Main Business ("NEAR")</u>
Bird & Sons	Chicago Bridge & Iron
Clow	Crane
Dorr-Oliver	Dravo
Ecodyne	FMC
Envirotech (Eimco, BSP, Wemco)	Merck (Baltimore Aircoil)
Marley	Research-Cottrell (Hamon)
Neptune Meter	Singer
Pennwalt (Wallace & Tiernan, Sharples)	Sunbeam (Illinois Water Treatment)
Rex Chainbelt	Sybron (Permutit)
	Westinghouse (Infilco)

IV. Air and Water Pollution Control Instrumentation

<u>As Major Part of Business Now ("IN")</u>	<u>As Peripheral to Main Business ("NEAR")</u>
Beckman	Envirotech (Sparling)
Fischer & Porter	Honeywell
Foxboro	Litton
General Signal (BIF)	Sybron (Taylor)
Leeds and Northrup	
Technicon	

V. Water Pollution - Specialty Chemicals

<u>As Major Part of Business Now ("IN")</u>	<u>As Peripheral to Main Business ("NEAR")</u>
Betz	Dow
Chemed (Dearborn)	DuPont
Mogul	Hercules
Nalco	Merck (Calgon)
	Monsanto
	Olin (Deady)
	Union Carbide
	Westvaco

SOURCE: Arthur D. Little, Inc., Estimates

TABLE I-14

**GROWTH RATES FOR SALES AND NET EARNINGS - SELECTED
"IN" COMPANIES**

(Compound Annual Growth Rate, %/Year)

Air Pollution Equipment - Particulate Control

	<u>Net Sales</u>		<u>Net Income After Taxes</u>	
	<u>1962-71</u>	<u>1966-71</u>	<u>1962-71</u>	<u>1966-71</u>
American Air Filter	9.7	10.5	9.5	6.4
Buffalo Forge	7.3	7.3	11.1	3.7
Envirotech	NA	52.4	NA	53.0
Peabody Galion	21.7	32.6	7.2	17.3
Research-Cottrell	29.8	37.8	18.3	27.5
Wheelabrator-Frye	14.7	15.0	8.1	22.8
Zurn	32.0	35.5	18.5	8.9

Water Pollution Control Equipment

Bird Machine	6.6	1.2 ³	15.9	(8.3)
Clow	11.1	11.0	6.4	3.7
Dorr-Oliver	5.2	(6.3) ¹	9.0	0.8
Envirotech	NA	52.4 ¹	NA	53.0
Ecodyne	20.6	NA	33.3	NA

Air and Water Pollution Control Instrumentation

Beckman	6.8	3.7	(2.4)	(4.2)
Fischer and Porter	14.2	8.8	14.7	3.2
Foxboro	10.4	7.3	8.1	(8.5)
General Signal	18.3	20.6	17.3	15.1
Leeds and Northrup	8.9	7.9	5.3	(4.1)
Technicon	27.4 ²	25.7	19.1	13.6

Water Pollution - Specialty Chemicals

Betz Laboratories	NA	17.8	NA	18.3
Chemed	NA	11.0	NA	8.0
Nalco Chemical	14.2	11.3	14.8	11.6

¹ 1970-72 Only

² 1964-1971

³ 1966-1970

SOURCE: Annual Reports, Moody's Industrial Manual

control equipment business the chemical companies have fared quite well, although it should be pointed out that the major part of their sales is for water treatment and not for waste treatment.

3. Profit on Sales for "In" Companies

For some "in" companies specific data are available from annual reports (Form 10-K) to the Securities and Exchange Commission (SEC) which show the percentage of sales and profits attributable to pollution control activities as compared to the entire operations of the company. Unfortunately, a corresponding breakdown for assets, equity and debt is not similarly available. A comparison of the net income to net sales figures can only give a rough indication of the profitability (i.e., margins) of the specific pollution control segment versus the rest of a company's business.

The year used for these comparisons was 1971. The analysis to follow (Part 4) shows that 1971 and 1969 were more normal years for this industry while 1970 was a recession year. The figures will not agree exactly with the return on sales figures in that analysis (Part 4) because a slightly different grouping of companies was used - relating to the availability of the data.

The summary of the 1971 return on sales percentages on the specific pollution parts of "in" (and some "near") companies is presented in Table I-15. The individual company data appear in Tables A-2 through A-5 in Appendix A.

The average return on specific sales of APC Equipment - Particulate was poorer than it was for all sales of the same companies and all sales of all the "in" companies. The average return on specific sales of WPC Equipment was essentially equivalent to the average return on all sales of these same companies and also all the "in" companies. In Instrumentation the return on specific sales was slightly better than the return on general sales for the same companies and essentially equivalent to the return on sales for all the "in" companies. The WPC Specialty Chemicals group average return on water-related sales was equal to the return on general sales for those companies and slightly better than the average return on sales for all of the "in" companies.

For all "in" company categories except APC Equipment - Particulate, the 1971 average return on specific pollution-related sales equaled or exceeded the average return on total company sales. In the APC Equipment - Particulate group the company average return on specific pollution control sales is poorer than the average return on all "in" company sales. Otherwise, the pollution business has equal or better margins than the non-pollution businesses of "in" companies.

4. Financial Ratios: "In" Versus "Near" Companies

The "in" and "near" companies presented in Table I-13 were analyzed according to three commonly used financial ratios. Because 1970 was a recession year, the analysis was extended to cover three years from 1969 through 1971. The companies were compared within their "in" and "near" groupings as well as on a company-by-company basis. The "near" or peripheral companies are prime candidates to expand their involvement in the

TABLE I-15

A COMPARISON OF THE AVERAGE RETURN ON SALES FOR
POLLUTION CONTROL COMPANIES

1971 Net Income After Tax/Sales Averages (%)

<u>Companies</u>	<u>Pollution Control Only - Specific "In" Companies</u>	<u>All Sales-- Specific "In" Companies</u>	<u>All Sales All "In" Companies</u>
APC Equipment - Particulate	2.6 (8)	3.3 (8)	3.6 (10)
WPC Equipment	3.6 (5)	3.6 (5)	3.5 (7)
APC & WPC Instrumentation	4.2 (4)	3.9 (4)	4.2 (8)
WPC-Specialty Chemicals	8.9 (3)	8.9 (3)	8.1 (4)

SOURCE: Securities & Exchange Commission Annual Reports (Form 10-K) and Company Prospectuses.

pollution control business. The financial ratios give both an indication of the incentive for the "near's" to become "in's" as well as a measure of the relative health of the "in's".

The pollution abatement industries were compared according to three common financial ratios. The ratio of net income after taxes to net sales was included because it is a common means of comparison. The ratio of net income after taxes to total assets was included because it is a common gauge of the general strength of a business. The ratio of total debt to equity was used as an indicator of the borrowing capacity of a company relative to other companies in the same industry. "Total assets" are just that – the total assets of the company. This should not be confused with the term "total investment" (stockholders' equity plus long-term debt), which is often used in financial comparisons. "Total debt" is defined as the difference between total assets and stockholders' equity. It, in turn, should not be confused with the definition of total debt as total long-term debt, which is also used in financial comparisons.

Ratios for the individual companies comprising the various groups are displayed in Tables A-6 through A-14 in Appendix A. Companies with unusual losses caused by unique circumstances during this period were omitted from the averages. This was done so that the resulting averages could be used as a measure of performance under "normal" circumstances.

Tables I-16 and I-17 present the financial ratio averages for the companies in the "in" and "near" categories for the five industries studied. Both "in" and "near" companies in all pollution control categories were affected by the recent recession. The dips in the ratios of net income to net sales and net income to total assets and a rise in the ratios of debt to stockholders' equity clearly displays this effect.

A comparison of the average financial ratios for the "in" group shows only one group for Air Pollution Control (APC) Equipment – that of Particulate Control. The WPC – Specialty Chemicals companies have the stronger financial record, both in terms of return on assets and debt to equity. The WPC Equipment companies show a 1971 turn-around in their return on assets. For the other three industries the return on assets ratio has declined slowly. The debt position has become stronger for companies in all categories as shown by the declining debt/equity ratios from 1970 to 1971.

In the "near" group the return on assets averages show that the APC Equipment – Particulate, APC Equipment – Gaseous, and Instrumentation categories have been performing about on a par. Again it is very clear that 1970 was a bad year. All 1971 average ratios show a stronger position as compared with 1970. The WPC – Specialty Chemicals category and the WPC Equipment category show a stronger financial position based on return on assets averages than the other three categories. When debt capacity is considered, the WPC – Specialty Chemicals category appears to be the strongest of all the "near" groups. The net income to net sales average ratios for APC Equipment – Gaseous is low – less than 3%. However, this category showed a better return on asset average than the APC Equipment – Particulate category.

A comparison of "in" averages with the "near" averages reveals that in the APC Equipment – Particulate group in the "in" category showed a slightly better return on assets average than did the "near" category. The "in" category also had a stronger debt position (lower debt to equity ratio) than the "near" category. This same comparison holds

TABLE I-16

FINANCIAL RATIO AVERAGES - SELECTED COMPANIES WITH MAJOR
PART OF BUSINESS IN POLLUTION CONTROL NOW

"IN"

		<u>APC Equipment (8)*</u>	<u>WPC Equipment (6)</u>	<u>APC and WPC Instrumentation (7)</u>	<u>WPC Specialty Chemicals (3)</u>
Net Income/ Net Sales (%)	1971	3.86	3.71	4.29	7.48
	1970	3.90	3.14	4.09	6.75
	1969	4.27	3.67	5.03	7.13
Net Income/ Total Assets (%)	1971	5.12	4.86	4.75	11.4
	1970	5.25	4.31	5.28	11.9
	1969	6.41	4.65	5.24	12.8
Total Debt/ Stockholders' Equity	1971	.856	.680	.718	.278
	1970	.975	.862	.851	.508
	1969	.892	.755	.889	.422

* Number of companies in category in parentheses.

SOURCES: Company Annual Reports and Moody's Industrial Manual

TABLE I-17

FINANCIAL RATIO AVERAGES - SELECTED COMPANIES WITH MINOR PART OF
BUSINESS IN POLLUTION CONTROL NOW

"NEAR"

		APC Equipment		WPC		APC and WPC		WPC Specialty	
		Particulate (4)	Gaseous (10)	Equipment (10)	Equipment (10)	Instrumentation (4)	Instrumentation (4)	Chemicals (7)	Chemicals (7)
Net Income/ Net Sales	1971	4.81	2.90	4.92	3.39	7.18			
	1970	4.25	2.75	4.55	3.21	6.89			
	1969	4.44	3.16	5.17	3.96	7.87			
Net Income/ Total Assets	1971	4.13	4.21	7.85	4.09	7.06			
	1970	3.74	3.80	7.37	3.98	6.86			
	1960	4.16	5.00	8.05	6.03	7.81			
Total Debt/ Stockholders' Equity	1971	1.55	1.02	1.09	1.18	.801			
	1970	1.54	1.02	1.11	1.45	.823			
	1969	1.39	.90	1.05	1.33	.771			

* Number of companies in category in parentheses.

SOURCES: Company Annual Reports and Moody's Industrial Manual

in comparing the "in" category averages with the APC Equipment - Gaseous "near" category averages. On balance, therefore, the pollution abatement business should already be attractive to the members of both the Gaseous and Particulate "near" groups. A critical ratio to watch in the future is the return on assets average for "in" companies. Marked improvement in this ratio, i.e., as a result of operating rate changes, would further enhance the attractiveness of the business to the "nears".

In the WPC Equipment group the return on assets for the "in's" is much lower than for the "near's". However, the debt reserve is greater for the "in's". There appears to be no financial incentive at the present time for the "nears" to become "ins". However, there are no major barriers either, and if greater returns come with better operating rates, greater interest will result.

In the Instrumentation group the "in's" show a stronger financial record than the "near's". Again as in the APC Equipment cases the critical factor is the trend in return on assets. A turn-around for the "in's" (i.e., improved operating rates) would make the business even more attractive to the "near's".

The financial performance of the "in's" of the WPC - Specialty Chemicals group has been substantially stronger than the "near" group averages. Except for the decreasing return on assets trend there should be good incentive for "nears" to become "ins".

Based on the preceding comparison the "in" companies are performing as well as the "near" companies. In some cases there is a moderate incentive for the "near" companies to become "ins". There are really no compelling financial arguments against the "near's" becoming more involved in the industries studied, particularly if operating rates improve. Of course, some of the "near's" may still not become "in's", if only because it is difficult for pollution control to become a major business of a corporation the size of DuPont or Westinghouse, for example.

5. Financial Ratios: Versus SIC Industries

As a still broader point of comparison to the "in" companies the three financial ratios were calculated from the general industry standard industrial classification statistics available from corporation income tax reports to the Internal Revenue Service (IRS). The latest available data are fiscal year 1968 (June 1968-June 1969). Companies with more than \$100 million in assets were chosen as those providing the most representative comparison.

Table I-18 and its accompanying list of definitions (Table I-19) present the results of the financial ratio analysis of the relevant IRS industries in fiscal year 1968-1969. Table I-18 lists the category and the specific standard industrial classification for the pollution control equipment and then the closest available general IRS industry standard industrial classification and the pertinent figures. As might be expected, differences in the figures are not large. SIC Industry 3440, Fabricated Structural Metal Products, shows the highest debt to equity ratio and the lowest net income to assets ratio. The related pollution control industry, APC Equipment - Gaseous, is just beginning to develop.

A comparison table of industry financial ratios is shown in Table I-20. In all cases the "in" companies performed better on a return on assets basis than the broad IRS groups. The smallest difference in return on assets appeared in the WPC Equipment. The largest appeared in the WPC-Specialty Chemicals comparison.

TABLE I-18

FINANCIAL RATIOS FROM INTERNAL REVENUE SERVICE

Industry & Specific SIC for Pollution Control	1968-1969 Corporation Closest Available IRS General Industry ¹ SIC	Income Tax Returns (Companies > \$100 Million in Assets)	
		Net Income Net Sales (%)	Net Income/ T. Assets (%) Total Debt/ Equity
APC Equipment - Particulate 3564	3560	4.61	4.45 0.780
APC Equipment - Gaseous 3443	3440	2.90	2.96 1.12
WPC Equipment - 35892 35851	3580	3.12	4.38 0.885
Instrumentation 3821 3823	3810	3.06	3.98 1.04
WPC Specialty Chemicals 28993	2892	4.43	4.46 0.889

¹ See Definitions on Table I-19.

SOURCE: Internal Revenue Service, Corporation Income Tax Returns - 1968

TABLE I-19

GENERAL INDUSTRY SIC CLASSIFICATIONS
AS USED BY THE INTERNAL REVENUE SERVICE

<u>SIC</u>	<u>Description</u>
2810	Manufacturing: Chemicals and Allied Products: Basic Chemicals, plastics and synthetics.
2898	Manufacturing: Chemicals and allied products: Chemical Products not elsewhere classified.
3440	Manufacturing: Fabricated metal products, except machinery and transportation: Fabricated structural metal products.
3560	Manufacturing: Machinery except electrical: General industrial machinery.
3580	Manufacturing: Machinery except electrical: Service industry machines.
3810	Manufacturing: Scientific instruments, photo- graphic equipment, watches and clocks: Scientific measuring instruments.

Source: Internal Revenue Service, Corporation Income Tax Returns 1968

TABLE I-20

A COMPARISON OF IN, NEAR, AND GENERAL INDUSTRY (IRS) STATISTICS

Category	% Net Income/Net Sales			% Net Income/Total Assets			Total Debt/Equity Ratio		
	IN	NEAR	IRS	IN	NEAR	IRS	IN	NEAR	IRS
APC Particulate Equipment	4.27	4.44	4.61	4.16	4.16	4.45	.892	1.39	0.780
APC Gaseous Equipment	-	3.16	3.16	-	5.00	2.96	-	0.90	1.12
WPC Equipment	3.67	5.17	3.12	4.65	8.05	4.38	.755	1.05	0.885
Instrumentation	5.03	3.96	3.06	5.24	6.03	3.98	.889	1.33	1.04
WPC Specialty Chemicals	7.13	7.87	4.43	12.8	7.81	4.46	.422	0.771	0.889

Since previous analysis shows that the financial ratios of the industry have not changed drastically from 1969 through 1971 this comparison of 1968-1969 data indicates that pollution control is in a good position relative to its general industry category. This is a promising sign for future supply needs.

6. Operating Rate Effects

Assuming that the pollution control businesses are presently at the commonly-reported 50% of capacity, an attempt was made to see how rapidly the profitability of these businesses would increase as sales were doubled.

A series of graphs were developed using estimates of the current percentages of sales which were fixed and variable costs. The calculations of these fixed and variable components for various IRS industry groups is shown in Table A-16 in Appendix A. Depending upon the industry, fixed costs vary from 20 to 30% of revenues while variable costs vary from 60 to 75%. Bureau of Census data for 1967 were used to initially estimate the material and labor percentages of sales. These numbers were later modified according to data gained from field interviews with industries. Other fixed and variable costs were estimated from 1968 Internal Revenue Service summaries of Corporate Income Tax Returns.

Figure I-2 and similar graphs in Appendix A (Figures A1-A5) are traditional break-even charts using revenues and costs calculated as a percentage of 1971 sales. Revenues and costs are plotted on the vertical axis while total sales are plotted on the horizontal axis. The 45-degree line originating from the zero point is the revenue line. The horizontal line represents fixed costs and the second line originating from the left at a point where the fixed cost line intersects the vertical axis is the sum of the total fixed and variable costs. The difference between the sales or revenue line and the total cost line is the earnings before interest and taxes (EBIT).

EBIT charts first show at what percent of the total 1970 sales the industry would break even, assuming fixed costs were not reduced. It should be emphasized that in reality the 200% current sales EBIT estimates are likely to be very optimistic, as the amount of fixed costs as a percentage of 1971 sales is not likely to remain constant while sales double.

The effect on EBIT of doubling 1971 sales for each of these categories is summarized in Table I-21. At double 1971 sales the Instrumentation category would benefit the most while the WPC-Specialty Chemicals and APC Equipment - Particulate categories would benefit least. The large Instrumentation return on sales increase reflects the high level of fixed costs (salaried labor) which this industry carries. The effect of doubling sales on the net income to total assets ratio is expected to be similar to the effect of doubling sales on net income to sales.

With the assumption that fixed costs remain constant, the profitability of the pollution control industries will increase with improved operating rates, and become much more attractive to potential entrants. By this measure, the Instrumentation industry theoretically has the greatest amount of potential gain.

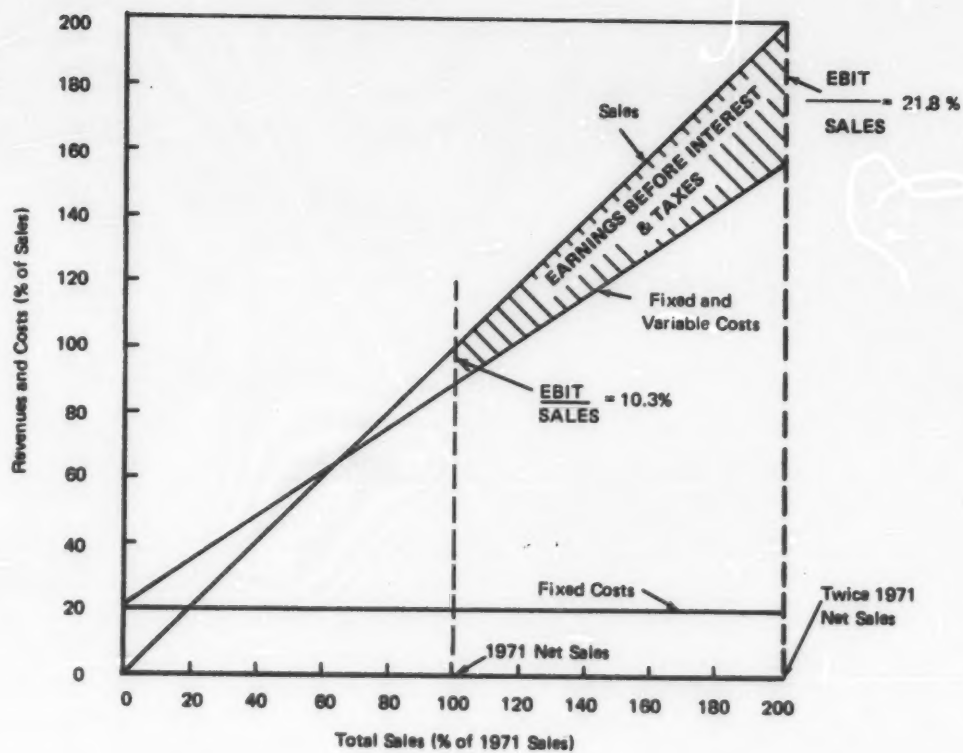


FIGURE I-2 EFFECT OF VARYING SALES ON EARNINGS BEFORE INTEREST AND TAXES: SPECIALTY CHEMICALS

TABLE I-21

ESTIMATED EFFECT ON PROFIT OF DOUBLING SALES

Category	APC Equipment- Particulate			APC Equipment- Gaseous		
	<u>3560</u>			<u>3440</u>		
IRS S.I.C.	At(b) Twice			At(b) Twice		
	(a) <u>1971</u>	1971 <u>Sales</u>	Ratio <u>b/a</u>	(a) <u>1971</u>	1971 <u>Sales</u>	Ratio <u>b/a</u>
Earnings Before Interest & Taxes/ Total Sales	10.0	21.2	2.1	5.7	15.0	2.6

IRS S.I.C.	<u>WPC Equipment</u>			<u>Instrumentation</u>			<u>WPC-Specialty Chemicals</u>		
	<u>3580</u>			<u>3810</u>			<u>2898</u>		
IRS S.I.C.	At(b) Twice			At(b) Twice			At(b) Twice		
	(a) <u>1971</u>	1971 <u>Sales</u>	Ratio <u>b/a</u>	(a) <u>1971</u>	1971 <u>Sales</u>	Ratio <u>b/a</u>	(a) <u>1971</u>	1971 <u>Sales</u>	Ratio <u>b/a</u>
Earnings Before Interest & Taxes Total Sales	6.9	17.1	2.5	6.6	22.8	3.5	10.3	21.8	2.1

7. Possible Sources of New Entrants

Many large companies in major industries have substantial resources available which could be committed to the production of pollution abatement equipment if the investment looked attractive enough in terms of profitability and if the needs for further supply were there. Chemical and aerospace companies are particularly promising candidates because of the related nature of their businesses and their already-observable interest in pollution control markets. In order to determine whether companies in these industries are likely to consider investment in the pollution control business, it is necessary to look at the return on investment which they are presently getting.

These ratios have been averaged for the companies in each industry group to obtain an indication of the return made by a "representative" company in the industry. However, since not all the companies in these industries have been included, the averages can only be a rough guide to the standards of performance. In analyzing these ratios, an attempt has been made to concentrate on general levels of profitability rather than focusing on trends.

a. Chemical Companies

As price competition, resulting from over-capacity, hit the chemical industry in the 1960's, the level of profitability declined. In an effort to recoup their position, many companies in this industry are looking for new investment to raise their rate of return back to earlier levels. Table I-22 shows that profitability varies significantly from company to company in this industry. The rate of return on stockholders' equity has dropped below 5% for some companies while others still maintain it at well over 10%. The level of debt tolerated by these companies also varies significantly from below one-third of stockholders' equity to 50% above stockholders' equity. However, none of these companies have excessive levels of debt given the magnitude of their assets. Due to the relatively high rates of return achieved by some chemical companies in the industry, we would expect that only a portion of the companies in the chemical industry would be attracted except in those product-markets (e.g., specialty chemicals) where the rate of return is up to their standards.

Companies producing chemicals for water pollution control have more favorable rates of return than many chemical companies (see Table I-22). As a result, it is likely that many companies in the chemical industry may begin investing in water pollution control chemicals. However, from the standpoint of relative profitability, other segments of the pollution abatement business probably do not look very attractive to the chemical industry.

b. Aerospace Companies

These companies traditionally operate (See Table I-23) on a very low net income to net sales ratio (2-4%) but have an adequate net income to stockholders' equity ratio (5-11%). McDonnell Douglas has fared relatively well in recent years, while the return for Boeing has been lower because of the depressed nature of the commercial airline industry. Boeing, along with Aerojet General, North American Rockwell, and Thiokol have also been adversely affected by cutbacks in defense spending — particularly the reduced demand for strategic-type weapons.

TABLE I-22

RESOURCES OF SELECTED CHEMICAL COMPANIES

Ratios in Percent

	<u>Dow</u>	<u>DuPont</u>	<u>Hercules</u>	<u>Monsanto</u>	<u>Olin</u>	<u>Union Carbide</u>	<u>Group Average</u>
Net Income/Net Sales							
1969	8.3	9.8	5.9	5.6	4.3	6.3	6.7
1970	6.8	9.2	6.5	4.0	2.4	5.2	5.7
1971	7.5	9.3	6.5	4.5	2.2	5.0	5.8
Net Income/Total Investment							
1969	5.7	10.3	5.6	5.4	4.6	5.5	6.2
1970	4.6	8.9	6.3	3.6	2.4	4.4	5.0
1971	5.0	8.9	6.8	4.4	2.1	4.3	5.2
Total Debt/Stockholders Equity							
1969	1.43	.29	1.00	.67	.76	.90	.84
1970	1.49	.26	.95	.80	.88	.97	.89
1971	1.57	.29	.71	.76	.98	.93	.87

SOURCES: Company Annual Reports, Moody's Industrial Manual and Standard and Poor's.

TABLE I-23

RESOURCES OF SELECTED AEROSPACE COMPANIES

		<u>Ratios in Percent</u>				
		<u>Aerojet General</u>	<u>Boeing</u>	<u>McDonnell Douglas</u>	<u>North American Rockwell</u>	<u>Thiokol</u> <u>Group Average</u>
Net Income/Net Sales						
1969	1.1	.4	3.9	2.4	2.9	2.1
1970	1.1	.6	4.5	2.7	1.9	2.2
1971	2.6	1.4	3.9	3.1	3.2	2.8
Net Income/Total Investment						
1969	2.0	.4	7.8	4.1	5.6	4.0
1970	1.9	.8	5.3	4.3	3.3	3.1
1971	3.2	1.7	3.8	5.0	5.3	3.8
Total Debt/Stockholders Equity						
1969	.95	2.27	1.63	1.11	.59	1.31
1970	.68	2.24	1.82	1.07	.50	1.26
1971	.76	1.92	1.94	.82	.57	1.20

SOURCES: Company Annual Reports, Moody's Industrial Manual and Standard and Poor's.

Aerospace companies tend to carry a relatively higher level of debt to stockholders' equity because of their ability to borrow relatively cheaply and thereby leverage their equity to obtain a higher rate of return for their stockholders.

With the cyclical nature of the aerospace business, these companies are likely to be interested in diversification into the pollution abatement equipment business as a stabilizing influence if the return on investment is attractive enough. Given their propensity to borrow and the relatively low level of profitability, it is likely that the pollution control equipment business will continue to interest the aerospace companies.

The profitability expectations of aerospace companies are similar in many respects to the profitability expectations of companies in the pollution abatement industry. The return on sales and investments tends to be on the low side in most segments of both industries (see Table I-23). Stockholders' return is maintained at a reasonable level by borrowing. A near-term investment in pollution control probably will appear attractive to aerospace companies who have experienced a softening of demand as government spending for strategic weapons has declined.

Chapter II. DEMAND ANALYSIS

A. INTRODUCTION

Before the future performance of the pollution abatement equipment industry may be assessed, detailed forecasts of demand for abatement equipment must be developed. This chapter first reviews our demand estimates of the equipment required by both the private and public sectors to meet existing federal air and water quality legislation. Following a discussion of methodology, estimates of total expenditures and component equipment shipments are compiled for each of the following sectors:

- Air Pollution Control
- Municipal Sewage Treatment
- Industrial Wastewater Treatment
- Wastewater Treatment Chemicals

The demand estimates were developed as an input upon which to evaluate the capability of the abatement equipment industry to supply the needs of the national pollution effort. As a result the specific objectives of the demand analysis were:

- 1) To determine the aggregate demand which will be placed upon the air and water pollution abatement industries over the period 1972-80.
- 2) To determine that portion of aggregate demand which will be available to equipment manufacturers in terms of total shipments and associated services.¹
- 3) To determine equipment markets by major product type for both air and water pollution abatement.

Following the derivation of total demand over 1972-1980, annual equipment shipments will be determined under each of three scenarios, where the cumulative annual expenditures within each may not exceed the ceiling dictated by the original air or water pollution demand estimate.

1. Data Resources

Two major kinds of data resources have been utilized for this study. The first may be classified as shipments or sales surveys and appear as periodic summaries of sales by the pollution abatement industries. These surveys are available through the Department of Commerce (DOC) or the various industry trade associations. This information provides the

¹The remaining expenditures were assumed to be available to the construction industry and beyond the concern of this study.

best basis for a cross-sectional breakdown of annual demand for air and water pollution equipment and serves as a historical backdrop for judging whether projected future growth rates are reasonable.

The second type of data resource may be classified as expenditure or purchases surveys where the *needs* of collective pollution control customers are analyzed and projected. The best examples of these resources are the microeconomic impact studies of various industries released by the Council on Environmental Quality, the Department of Commerce (DOC), and the Environmental Protection Agency.² These studies are less useful for individual product breakdowns and determinations of the present business activity. However, they remain the best resources for projecting the potential levels of *aggregate* demand (i.e., how much needs to be spent over some time period). Other examples of this kind of data are the annual studies compiled by EPA and presented in its annual reports to Congress, and several inter-industry surveys taken by trade associations (e.g., the Manufacturing Chemists Association).

2. Demand Estimates

Published estimates of the cost of pollution control vary considerably depending both upon the agency or organization releasing the information and upon the level of treatment, timetable, and cost models used in the analysis. In general, the demand estimates presented here vary from those of other published sources due to the following:

- 1) Most publicly available studies have been carried out for the purpose of determining the economic impact on either a particular industry or on the commodity costs and prices within that industry. Our demand estimates represent the markets available to the suppliers of pollution abatement equipment as a result of those anticipated expenditures.
- 2) Often the costs given (in current dollars) are annualized over a specified period, and no distinction is made between capital investment costs, annual operating and maintenance costs, replacement costs and capital costs. Our major demand estimates are shown in constant 1972 dollars and represent capital investment costs only – with the exception of the demand for wastewater treatment chemicals.
- 3) Most cost of control studies vary in terms of their assumed coverage, compliance deadlines, and level of treatment. Our estimates cover both existing and new source facilities over the period 1972-80, and are premised upon achieving presently existing federal legislation.³

²The *Economic Impact of Pollution Control*, March 1972.

³This demand analysis does not incorporate the effects of the three-year \$24.6 billion *Amendments to the Federal Water Pollution Control Act* passed by Congress just prior to its adjournment in October 1972.

Admittedly, our estimates of demand are based upon a "best efforts" basis. While we believe that extensive micro-demand studies on each of the many polluting sectors would guarantee a more accurate data base from which to start, we realize that this analysis cannot wait for the consummation of that ideal situation. Our policy has been to accept the most recent estimates available providing they offered sufficient detail by which to fulfill the requirements of the study.

In an attempt to qualify our estimates, we have listed our major assumptions. However, many of the equipment demand estimates are a function of our perception of emerging changes in the application of predominant equipment types and treatment methods. When appropriate, trends in equipment mix were forecasted in order to introduce the realities of changing technology, treatment economics, and standards.

Our macro-estimates of the cost of pollution abatement agree with recently released government estimates, and several of our industry contacts have indicated that our equipment market estimates are similar to those used in their in-house marketing efforts.

Finally, we are of the opinion that our cumulative demand estimates are consistent with established national needs over the period 1972-1980. While we recognize that accurate estimates are not the primary objective of this study, we have attempted to accept only what we believe to be acceptable figures inasmuch as these estimates are critical to our evaluation of the abatement industry's ability to meet such demand.

3. Methodology

Activity within the pollution abatement field may be considered in one of three major sectors - air pollution control, municipal sewage treatment, and industrial wastewater treatment. Each of these sectors was treated independently in the demand analysis along with the addition of a fourth - wastewater treatment chemicals.

Figure II-1 shows our general methodology in developing the demand estimates under different scenarios. First, the capital investment required to meet the level of treatment prescribed by existing federal legislation was devised using the cost models and growth factors available within recent government or in-house ADL studies. In addition, a summary showing historical construction activity within the sector was compiled using DOC and/or industry trade association data.

Three major scenarios (or alternative futures) were developed for each sector. These may be further described as follows:

Case I: Baseline

Estimates the level of annual construction (and equipment shipment) activity over the period 1972-80 under the assumption that no major federal environmental legislation had been passed. After selecting a base year (e.g., that year after which annual construction activity was noticeably affected by federally-imposed standards or financial assistance), an average growth factor was devised which represented the rate at which capital expenditures would have occurred in the absence of environmental legislation. The breakdown of equipment by product type over the period 1972-80 was extrapolated using the equipment mix existing in the base year.

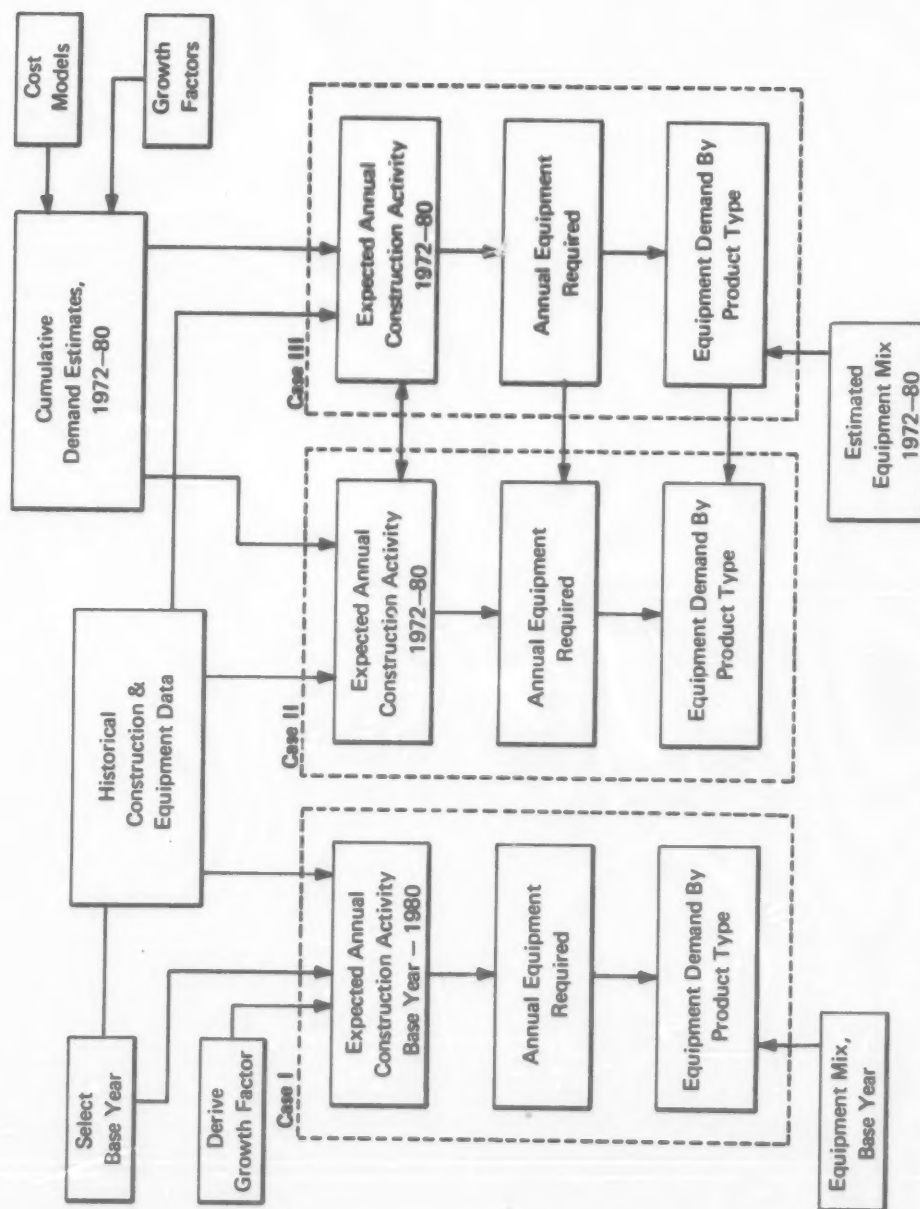


FIGURE II-1 DEMAND ANALYSIS METHODOLOGY

Case II: Federal Compliance Schedule

Estimates the level of annual construction activity required within the period 1972-80 in order to meet existing federal standards by certain target years (1975 for air pollution control, 1976 for water). Using estimated 1971 expenditures as a base, annual expenditures were forecasted showing peaks of activity occurring just before or during those deadline years. The breakdown of annual equipment shipments by product type for Case II was not finalized until the Case III estimates were completed. The cumulative mix of equipment shipments in Case II was thereby distributed according to the ratio of the moving cumulative total expenditures in Case III.

Case III: Expected Compliance Schedule

This might also be described as our "best guess" or more reasonable alternative case. Generally speaking, it estimates the pattern of investment activity that would be required to meet existing federal standards by 1980. It is within the context of this scenario that we first applied our projections of technical advancement, equipment mix, and treatment economics. Estimates of the growth rates within each pollution abatement sector were based partly upon our evaluation of recent and current capability activity within both the public and private sectors.

In both Cases II and III above, the estimated capital investment within each sector was used as a ceiling so that cumulative annual expenditures would not exceed estimated needs prior to 1980. In Case I, it was held that the cumulative expenditures over the period from the base year through 1980 could not exceed the sum of the estimated needs, 1972-80, plus the actual (constant dollar) expenditures made from the base year through 1971.

The availability (and credibility) of the data used plus our assumptions in revising the data is discussed pursuant to our development of estimated needed investment within each of the individual sectors.

B. AIR POLLUTION CONTROL

Air pollution control expenditures were subdivided into the very different problems of particulate control and gaseous control. Within each of those categories, total expenditures were further divided between abatement equipment proper ("flange-to-flange" equipment) and the associated construction equipment and services required for installation. The type and extent of associated installation services required for a particular project will depend upon the selected control hardware, accessory equipment, gas volume flow, physical location, and type of facility -- new or existing. Our estimates of the associated installation expenditures are a function of the mix of product types⁴ shipped during that year. These estimates of associated expenditures are as follows:

⁴A short description of the major types of air pollution control equipment is given in Table B-1, Appendix B.

TABLE II-1
ASSOCIATED INSTALLATION EXPENDITURES
OF AIR POLLUTION CONTROL EQUIPMENT

<u>Product Type</u>	<u>Associated Installation Costs</u> <u>As Added Percent of Equipment Cost</u>
Particulate Control:	
Electrostatic Precipitators	150%
Fabric Filters	150
Mechanical Collectors	100
Scrubbers	300
Gaseous Control:	
Scrubbers	400
Incinerators, Adsorbers, etc.	75

In addition to specialty equipment and associated installation estimates, instrumentation shipments were forecasted. This category is defined to include samplers, analyzers, monitors, and controllers.

1. Past Activity

Reliable information on annual shipments of air pollution control hardware originates from two sources: the Department of Commerce and the Industrial Gas Cleaning Institute (IGCI).

For the years 1963 and 1967, DOC surveyed the shipments of "gas cleaning equipment" by major product types (essentially those in Table II-1). While the DOC results are well regarded, they exist only for two years mentioned above and must be supplemented for the period since 1967.

The second and more consistent source of information, IGCI, annually makes public releases of summarized statistics reporting the "flange-to-flange" equipment billings of its members. As IGCI's membership does not represent complete coverage of the market, certain adjustments must be made in order to derive total annual shipments by product type.

Table II-2 contains our estimates on air pollution control equipment shipments for the period 1963 through 1971. These estimates are based primarily upon IGCI data but have been adjusted. While we estimate that the "old IGCI" of 12 members (pre-1963) represented only about 65% of total annual sales, we believe that the increase in membership (29 in 1971) has brought IGCI's reported billings up to 90% of actual sales (for particulate control equipment) during 1971.

A review of the companies comprising each of five product divisions has permitted us to subjectively adjust IGCI product line volumes. Briefly, we suspect that few electrostatic

TABLE II-2

AIR POLLUTION CONTROL
ANNUAL EQUIPMENT SHIPMENTS, 1963-71^a

	Annual Shipments (Millions of Current Dollars)						Growth (%/year)	
	1963	1967	1968	1969	1970	1971	1963-67	1967-71
Particulate Control								
Electrostatic Precipitators	13.9	36.5	42.0	39.5	63.5	93.0	27.2	26.4
Fabric Filters	14.5	21.7	29.5	35.0	37.5	57.5	10.6	27.6
Mechanical Collectors	10.5	22.4	18.0	21.0	21.5	20.0	20.5	
Scrubbers	11.1	19.2	22.0	20.5	22.0	23.0	14.7	4.6
Total	50.0	99.8	111.5	116.0	144.5	193.5	18.9	18.0
Gaseous Control								
Scrubbers	1.0 ^c	6.8	6.0	6.0	10.0	14.0	--	19.8
Incinerators, Adsorbers ^b	4.0 ^c	10.0	15.0	20.0	23.5	25.5	--	26.4
Total	5.0	16.8	21.0	26.0	33.5	39.5	--	23.8
GRAND TOTAL ^d	55.0	116.6	132.5	142.0	178.0	233.0	20.7	18.9

^aFlange-to-flange equipment only.^bIncludes thermal, flame, and catalytic incineration; gas adsorption.^cRough estimate.^dWe estimate an additional 100% of this figure was available to equipment manufacturers in terms of associated services.

SOURCE: Industrial Gas Cleaning Institute; Department of Commerce; Arthur D. Little, Inc. estimates.

precipitators are sold by non-IGCI companies. Likewise, membership billings of fabric collectors should show excellent market coverage with only W.W. Sly and Hart-Carter missing from the list of members contributing to the data. Membership billings probably account for a smaller portion of the market for both wet scrubbers and mechanical collectors, inasmuch as the latter are easily fabricated by non-institute members. IGCI's reported billings in gaseous control are so minimal that we have chosen to ignore them completely.

The importance of accurate data showing annual shipments of control equipment hardware will be seen within the following section. The cost of control estimates developed represent the total capital investment required, *not* capital investment in equipment only. Therefore, since no governmental agency or industrial organization compiles statistics on the total installation expenditures for air pollution control, our estimates of annual investment are based solely upon estimated annual equipment shipments.

2. Demand Forecasts

Estimates of the total investment required to meet existing federal legislation prior to 1980 were distributed between three sectors: industrial processes, steam-electric power generation, and solid waste incineration.

Table B-2 (Appendix B) summarizes our estimates on an industry-by-industry basis of the capital investment required to control emissions from stationary source industrial processes. These estimates include control of both existing and new source facilities. The estimates for 19 of the 21 industries are based upon the methodology studies⁵ used by EPA in compiling its 1972 *Economics of Clean Air*. Note that an unassigned investment of \$740 million is included in the \$5,966 million total shown in Table B-1 to account for those industries not listed.

The estimated cost of control for the second sector, steam-electric power generation, is shown in Table B-3. The 125,000 megawatt capacity estimated to require emission control in 1975 is based upon a recently completed EPA study,⁶ and assumes a control cost (for both particulates and SO₂) of \$50 per kilowatt hour. On that basis, the pollution bill for retrofitting existing plants is \$5 billion. A new source growth of 6%/year was assumed from 1976 to 1980, bringing the total cost of control to \$6.73 billion.

It should be noted that present control of SO₂ from coal-fired electric generating plants is virtually non-existent, largely because of the lack of commercially proven technology. The *Federal Register* of March 21, 1972, lists 20 prototype SO₂ removal systems which are presently planned or operating, but these are still in proving stages.

Our estimates of the cost of control of solid waste incineration, the third and final sector, is given in Table B-4. While an estimate of these costs was published in the 1972 *Economics of Clean Air*, we were hesitant to accept the associated assumption that the closing of open

⁵Unpublished studies provided to us by EPA established cost of control models, emission factors, and growth factors for each industry.

⁶"Flue Gas Cleaning Process Commercial Availability," Task Order No. 9, prepared for the Office of Air Programs by Process Research, Inc., September 1972.

dumps would cause active municipal incineration capacity to double by 1975. Our estimates of required capital investment is therefore based upon a previous ADL study.⁷ Using the ADL study we were able to assume various cost of control factors depending upon whether incineration capacity represented new source or retrofit installations, and in the latter case, the breakdown by age of the installed capacity.

Our total estimate of the capital investment required to meet full compliance is the sum of Tables B-2, B-3, and B-4 and is shown in Table II-3.

With the exception of incineration, the models used (in the EPA methodology studies) to estimate the cost of control for each of the above sectors were in most cases devised around a single type of control hardware. To extrapolate annual demand for air pollution control equipment on this basis, would, in our opinion, present a distorted picture of the equipment mix of future demand. Therefore, we have used the \$12.8 billion estimate as a demand ceiling, and have allocated expenditures among the various equipment types by the process explained in Case III below.

3. Case I: Baseline

Our estimated expenditures for air pollution control under the absence of environmental legislation are based upon activity within the field as of 1963. We have assumed that the "dust collection business" change drastically with the passage of the Clean Air Act (1963), its subsequent amendments (1965, 1970), and the Air Quality Act (1967).

To develop a hypothetical baseline case, three inputs were needed: 1) total equipment shipments in 1963; 2) market growth, 1963-1980; and 3) the breakdown of shipments by product type.

Total equipment shipments, expressed in current dollars, were available from the DOC survey of 1963. As air pollution control equipment per se is not included within any single SIC category, conversion to 1972 constant dollars was accomplished using an unweighted average of the comparative price indices for SIC categories 344 (fabricated structural steel), 356 (general industrial machinery), and 358 (service industry machinery).

Annual equipment shipments were assumed to grow at a rate equal to the growth of industrial plant investment. To reflect this, we turned to government statistics on Fixed Investment for Producers' Durable Equipment under Gross Private Domestic Investment, as reported in the National Income and Product Accounts. As indicated in Table B-4, the average annual growth of that indicator for the period 1963-1971 was 7.6%/year. The estimated projections of activity from 1972 to 1980 were taken from the ADL Input/Output Model of the National Economy which indicates an average growth of 5.4%/year.

The distribution of annual equipment shipments by product type was assumed equal to the percentage distribution in 1963, as reported in the DOC survey. In doing so, we assumed that the incentive to select alternative (e.g., upgraded) equipment is fostered by a stiffening of the emission standards through Federal legislation, and that there was little incentive on

⁷"A Systems Study of Air Pollution from Municipal Incineration," Contract CPA-22-69-23, prepared for the National Air Pollution Control Administration by Arthur D. Little, Inc., March 1970.

TABLE II-3

AGGREGATE INVESTMENT NEEDS IN AIR POLLUTION CONTROL, 1972-80

(refer to Tables B-2 to B-4 in Appendix B)

<u>Source</u>	<u>Cost of Control (millions of 1972 dollars)</u>	
	<u>Particulate</u>	<u>Gaseous^a</u>
Industrial Processes ^b		
Natural Gas Production	-	52
Petroleum Refining	231	154
Copper	-	374
Lead	-	40
Zinc	-	33
Sulfuric Acid	-	206
All Others	4,876	-
Steam-Electric Power Generation	-	6,730
Incineration	<u>94</u>	<u>-</u>
TOTALS	5,201	7,589
GRAND TOTAL	\$12,790	or \$12.8 billion

^a Sulfur dioxide control by wet scrubbing; assumed \$50 per kwh for power generation

^b Estimates based upon 1972 Economics of Clean Air.

SOURCE: Environmental Protection Agency; Arthur D. Little, Inc., estimates.

the part of industrial customers in 1963 to substitute for those systems which had established an economic advantage.

Estimated annual expenditures (and equipment shipments) for the baseline case are shown in Table II-4. Future estimates of instrumentation shipments were derived as a constant percentage of equipment shipments in any particular year.

4. Case II: Federal Compliance Schedule

This scenario is built around a federal compliance deadline of mid-1975 in order to be consistent with the deadlines for compliance to primary standards. In addition, the status of SO₂ control technology made it imperative to distinguish between two situations:

Case IIa: Assumes present gaseous control technology is unacceptable and that further difficulties will continue to occur over the short term in developing the current candidate systems. The annual expenditures shown in Table II-5 were estimated under the assumption that federal and state enforcement agencies would require adequate particulate control of steam-electric power sources in the absence of acceptable gaseous control technology.

Case IIb: Assumes acceptable gaseous control technology is available to meet the 1975-77 deadlines. The expenditures shown in Table II-6 for particulate and gaseous control equipment are dictated by the previously estimated needs (Table II-3) of \$5.2 billion and \$7.6 billion, respectively.

In general, the major distinction between Cases IIa and IIb is the cumulative investment in particulate control equipment over the period 1975 to 80. Under Case IIa, investment in particulate control equipment is sustained by the need to control coal burning power plants using conventional equipment such as electrostatic precipitators, whereas a proven wet scrubbing system (Case IIb) could control both gaseous and particulate emissions.

A schedule of the estimated actual expenditures required to strictly meet federal standards as promulgated would have shown a peak of equipment demand in 1975, and followed in 1976 by a fall in demand to the level of investment required to control only new sources. The estimated expenditures presented in Tables II-5 and II-6 have been adjusted slightly to account for some granting of extensions to certain states in carrying out their Implementation Plans. This action effectively reduces maximum demand in the years 1974-1975, and results in a continuance of a retrofit market beyond 1975.

5. Case III: Expected Compliance Schedule

As in Case II, this scenario is further divided into two subcases, IIIa and IIIb, under the assumptions discussed previously concerning the present status of gaseous control technology.

In both Cases IIIa (Table II-7) and Case IIIb (Table II-8) the establishment of particulate control technology insures a continuing APC market, although there are indications that

TABLE II-4
CASE I: BASELINE

AIR POLLUTION CONTROL
ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditure (millions of 1972 dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Particulate Control:												
Electrostatic Precipitators	29	31	33	34	36	38	40	42	44	46		
Fabric Filters	30	32	34	36	38	40	42	44	46	49		
Mechanical Collectors	22	23	24	26	27	29	30	32	34	35		
Scrubbers	23	25	26	28	29	30	32	34	36	37		
Total equipment ^b	104	111	117	124	130	137	144	152	160	167		
Associated installation ^c	180	193	203	215	225	236	249	263	277	289		
TOTAL	284	304	320	339	355	373	393	415	437	456		
Gaseous Control:												
Scrubbers	2	2	2	2	3	3	3	3	3	3		
Incinerators, adsorbents	8	9	9	10	10	11	11	12	12	13		
Total equipment ^b	10	11	11	12	13	14	14	15	15	16		
Associated installation ^d	34	38	38	42	43	47	47	51	51	55		
TOTAL	44	49	49	54	56	61	61	66	66	71		
Total All Equipment	114	122	128	136	143	151	158	167	175	183		
Total Associated Installation ^e	214	231	241	257	268	283	296	314	328	344		
Instrumentation ^f	8	8	8	9	9	10	10	11	11	12		
GRAND TOTAL	336	361	377	402	420	440	464	492	514	539	5.4	5.4

^aStationary sources only; omits automotive emission control.

^bFlange-to-flange equipment only.

^cIncludes erection, insulation materials, equipment transportation, liquid treatment systems for scrubbers, fans, ductwork, motors, and other auxiliary equipment. Assumed added installation costs as follows: Precipitators 150% (of equipment cost); Fabric Filters 150%; Mechanical Collectors 100%; Scrubbers 300%.

^dSame as previous footnote. Assumed added installation costs as follows: Scrubbers 400%; Incinerators, Adsorbents 75%.

^eRepresents total installation costs, we estimate 50% of this figure is available to equipment manufacturers in terms of associated services.

^fIncludes samplers, analyzers, monitors, and controllers.

SOURCE: Arthur D. Little, Inc. estimates.

TABLE II-5

CASE II: FEDERAL COMPLIANCE SCHEDULE

a. PRESENT GASEOUS CONTROL TECHNOLOGY

AIR POLLUTION CONTROL

ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditure (millions of 1972 dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Particulate Control:												
Electrostatic Precipitators	97	124	186	297	480	263	127	74	48	40	49.1	-39.2
Fabric Filters	60	73	107	171	293	174	92	51	32	24	48.9	-39.5
Mechanical Collectors	20	21	28	39	64	35	19	11	7	5	33.7	-40.0
Scrubbers	24	29	40	63	96	58	31	15	10	9	41.4	-37.7
Total equipment ^b	201	247	361	570	935	530	269	151	97	78	46.8	-39.2
Associated installation ^c	330	404	588	931	1515	865	441	244	157	128	46.4	-39.0
TOTAL	531	651	949	1501	2450	1395	710	395	254	206	46.6	-39.1
Gaseous Control:												
Scrubbers	15	19	26	41	72	146	127	85	67	58	48.0	-4.2
Incinerators, adsorbers	27	31	40	54	80	97	37	14	9	6	31.2	-60.4
Total equipment ^b	42	50	66	95	152	243	164	99	76	64	37.9	-15.9
Associated installation ^d	80	100	134	205	348	657	536	351	274	236	35.3	-7.5
TOTAL	122	150	200	300	500	900	700	450	350	300	42.3	-9.7
Total All Equipment	243	297	427	665	1087	773	433	250	173	142	45.4	-33.5
Total Associated Installation ^e	410	504	722	1136	1863	1522	977	595	431	364	46.0	-27.9
Instrumentation ^f	15	28	40	62	102	80	49	29	21	17	61.4	-30.1
GRAND TOTAL	668	829	1189	1863	3052	2375	1459	874	625	523	46.2	-29.7

^a Stationary sources only; omits automotive emission control.^b Flange-to-flange equipment only.^c Includes erection, insulation materials, equipment transportation, liquid treatment systems for scrubbers, fans, ductwork, motors, and other auxiliary equipment. Assumed added installation costs as follows: Precipitators 150% (of equipment cost); Fabric Filters 150%; Mechanical Collectors 100%; Scrubbers 300%.^d Same as previous footnote. Assumed added installation costs as follows: Scrubbers 400%; Incinerators, Adsorbers 75%.^e Represents total installation costs, we estimate 50% of this figure is available to equipment manufacturers in terms of associated services.^f Includes samplers, analyzers, monitors, and controllers.

SOURCE: Arthur D. Little, Inc. estimates.

TABLE II-6

CASE II: FEDERAL COMPLIANCE SCHEDULE

b. ADEQUATE GASEOUS CONTROL TECHNOLOGY

AIR POLLUTION CONTROL

ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditure (millions of 1972 dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Particulate Control:												
Electrostatic Precipitators	97	110	129	170	254	109	75	62	49	41	27.2	-30.6
Fabric Filters	60	65	74	98	157	72	54	43	33	25	27.2	-30.8
Mechanical Collectors	20	20	20	22	34	15	11	9	7	5	14.2	-31.9
Scrubbers	24	26	28	36	51	24	18	12	10	9	20.7	-29.3
Total equipment ^b	201	221	251	326	496	220	158	126	99	80	25.3	-30.6
Associated installation ^c	330	361	409	532	804	359	259	203	161	132	24.9	-30.3
TOTAL	531	582	660	858	1300	579	417	329	260	212	25.1	-30.4
Gaseous Control:												
Scrubbers	15	19	36	81	182	428	337	121	97	88	86.5	-13.5
Incinerators, adsorbers	27	31	40	54	80	97	37	14	9	6	31.2	-40.4
Total equipment ^b	42	50	76	135	262	525	374	135	106	94	57.9	-18.5
Associated installation ^d	80	100	174	365	798	1785	1376	495	394	356	77.0	-14.7
TOTAL	122	150	250	500	1050	2310	1750	630	500	450	71.2	-15.6
Total All Equipment	243	271	327	461	758	745	532	261	205	174	32.9	-25.5
Total Associated Installation ^e	410	461	583	897	1592	2144	1635	698	555	488	40.4	-21.1
Instrumentation ^f	15	25	31	43	71	70	50	25	19	16	47.5	-25.8
GRAND TOTAL	668	757	941	1401	2421	2959	2217	984	779	678	38.0	-22.5

^a Stationary sources only; omits automotive emission control.

^b Flange-to-flange equipment only.

^c Includes erection, insulation materials, equipment transportation, liquid treatment systems for scrubbers, fans, ductwork, motors, and other auxiliary equipment. Assumed added installation costs as follows: Precipitators 150% (of equipment cost); Fabric Filters 150%; Mechanical Collectors 100%; Scrubbers 300%.

^d Same as previous footnote. Assumed added installation costs as follows: Scrubbers 400%; Incinerators, Adsorbers 75%.

^e Represents total installation costs, we estimate 50% of this figure is available to equipment manufacturers in terms of associated services.

^f Includes samplers, analyzers, monitors, and controllers.

TABLE II-7

CASE III: EXPECTED COMPLIANCE SCHEDULE

a. PRESENT GASEOUS CONTROL TECHNOLOGY

AIR POLLUTION CONTROL

ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditure (millions of 1972 dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Particulate Control:												
Electrostatic Precipitators	97	108	120	146	162	175	183	203	220	223	13.7	6.6
Fabric Filters	60	63	69	83	93	103	111	128	144	158	11.6	11.2
Mechanical Collectors	20	18	19	21	21	23	24	27	29	30	7.4	7.4
Scrubbers	24	25	26	31	34	38	39	37	48	50	9.1	8.0
Total equipment ^b	201	214	234	281	310	340	357	395	441	471	11.4	8.7
Associated installation ^c	330	350	381	458	506	556	583	635	719	766	11.3	8.6
TOTAL	531	564	615	739	816	896	940	1030	1160	1237	11.3	8.7
Gaseous Control:												
Scrubbers	15	17	22	29	35	49	69	100	126	160	23.6	35.5
Incinerators, adsorbers	27	29	31	33	35	37	39	42	45	48	6.7	6.5
Total equipment ^b	42	46	53	62	70	86	108	142	171	208	13.6	24.3
Associated installation ^d	80	90	111	141	166	224	305	432	538	676	20.0	32.4
TOTAL	122	136	164	203	236	310	413	574	709	884	17.9	30.2
Total All Equipment	243	260	287	343	380	426	465	537	612	679	11.8	12.3
Total Associated Installation ^e	410	440	492	599	672	780	888	1067	1257	1442	13.1	16.5
Instrumentation ^f	15	20	25	31	40	46	53	61	70	80	27.8	14.9
GRAND TOTAL	668	720	804	973	1092	1252	1406	1665	1939	2201	13.1	15.0

^a Stationary sources only; omits automotive emission control.^b Flange-to-flange equipment only.^c Includes erection, insulation materials, equipment transportation, liquid treatment systems for scrubbers, fans, ductwork, motors, and other auxiliary equipment. Assumed added installation costs as follows: Precipitators 150% (of equipment cost); Fabric Filters 150%; Mechanical Collectors 100%; Scrubbers 300%.^d Same as previous footnote. Assumed added installation costs as follows: Scrubbers 400%; Incinerators, Adsorbers 75%.^e Represents total installation costs, we estimate 50% of this figure is available to equipment manufacturers in terms of associated services.^f Includes samplers, analyzers, monitors, and controllers.

SOURCE: Arthur D. Little, Inc. estimates.

TABLE II-8

CASE III: EXPECTED COMPLIANCE SCHEDULE

b. ADEQUATE GASEOUS CONTROL TECHNOLOGY

AIR POLLUTION CONTROL

ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditures (millions of 1972 dollars)										Growth (%/Year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Particulate Control:												
Electrostatic Precipitators	97	108	120	146	162	165	146	79	52	36	13.7	-26.0
Fabric Filters	60	63	69	83	93	97	89	50	34	25	11.6	-23.1
Mechanical Collectors	20	18	19	21	21	22	19	10	7	5	1.2	-24.9
Scrubbers	24	25	26	31	34	36	31	14	11	8	9.1	-25.1
Total Equipment ^b	201	214	234	281	310	320	285	153	104	74	11.4	-24.9
Associated Installation ^c	330	350	381	458	506	523	465	246	169	121	11.3	-24.9
TOTAL	531	564	615	739	816	843	750	399	273	195	11.3	-24.9
Gaseous Control:												
Scrubbers	15	22	32	53	78	110	160	250	282	296	51.0	30.6
Incinerators, adsorbers	27	29	31	33	35	37	39	42	45	48	6.7	6.5
Total Equipment ^b	42	51	63	86	113	147	199	292	327	344	28.1	24.9
Associated Installation ^d	80	110	151	237	338	468	669	1,032	1,162	1,220	43.4	29.3
TOTAL	122	161	214	323	451	615	868	1,324	1,489	1,564	38.7	28.2
Total All Equipment	243	265	297	367	423	467	484	445	431	418	14.9	-0.2
Total Associated Installation ^e	410	460	532	695	844	991	1,134	1,278	1,331	1,341	19.8	9.7
Instrumentation ^f	15	20	25	31	40	46	53	61	70	80	27.8	14.9
GRAND TOTAL	668	745	854	1,093	1,307	1,504	1,671	1,784	1,832	1,839	18.3	7.1

^a Stationary sources only; omits automotive emission control.^b Flange-to-flange equipment only.^c Includes erection, insulation materials, equipment transportation, liquid treatment systems for scrubbers, fans, ductwork, motors, and other auxiliary equipment. Assumed added installation costs as follows: Precipitators 150% (of equipment cost); Fabric Filters 150%; Mechanical Collectors 100%; Scrubbers 300%.^d Same as previous footnote. Assumed added installation costs as follows: Scrubbers 400%; Incinerators, Adsorbers 75%.^e Represents total installation costs, we estimate 50% of this figure is available to equipment manufacturers in terms of associated services.^f Includes samplers, analyzers, monitors, and controllers.

SOURCE: Arthur D. Little, Inc., estimates.

industrial investment in air pollution control may have slackened recently. This is caused in part by confusion on behalf of private sector customers concerning deadlines. Our estimates for particulate control expenditures indirectly assume that this recent slippage in demand will be overcome beginning in 1974. Then, following the 1975 deadlines, it will again recess to a slower growth rate.

On the other hand, Case IIIa assumes that the demand for gaseous control equipment will *not* materialize until an economic and technically feasible SO₂ control system has been developed. Currently, wet scrubbing systems appear to be the forerunners of development. With this in mind, our estimates of gaseous control in Case IIIa activity allow a healthy, although somewhat dampened, growth until 1975-76, at which time we have anticipated the adopting of a kind of "best practical technology" policy by EPA which will substantially increase the rate of annual expenditures.

In Case IIIb, expenditures for gaseous control begin a high-growth rate immediately assuming that current technology is adequate for meeting the inferred 1975-77 deadlines.

The future mix of equipment for both particulate and gaseous control will also be somewhat affected by both the collection efficiencies of alternative hardware and the emerging New Source Performance Standards. In attempting to judge this emerging equipment mix for particulate control, our perception of the trade-offs between control hardware which will occur during the decade are shown in Figure B-1 (Appendix B). Making linear interpolations between the percentages shown, particulate control demand estimates by product type were calculated and are shown in Tables II-7 and II-8.

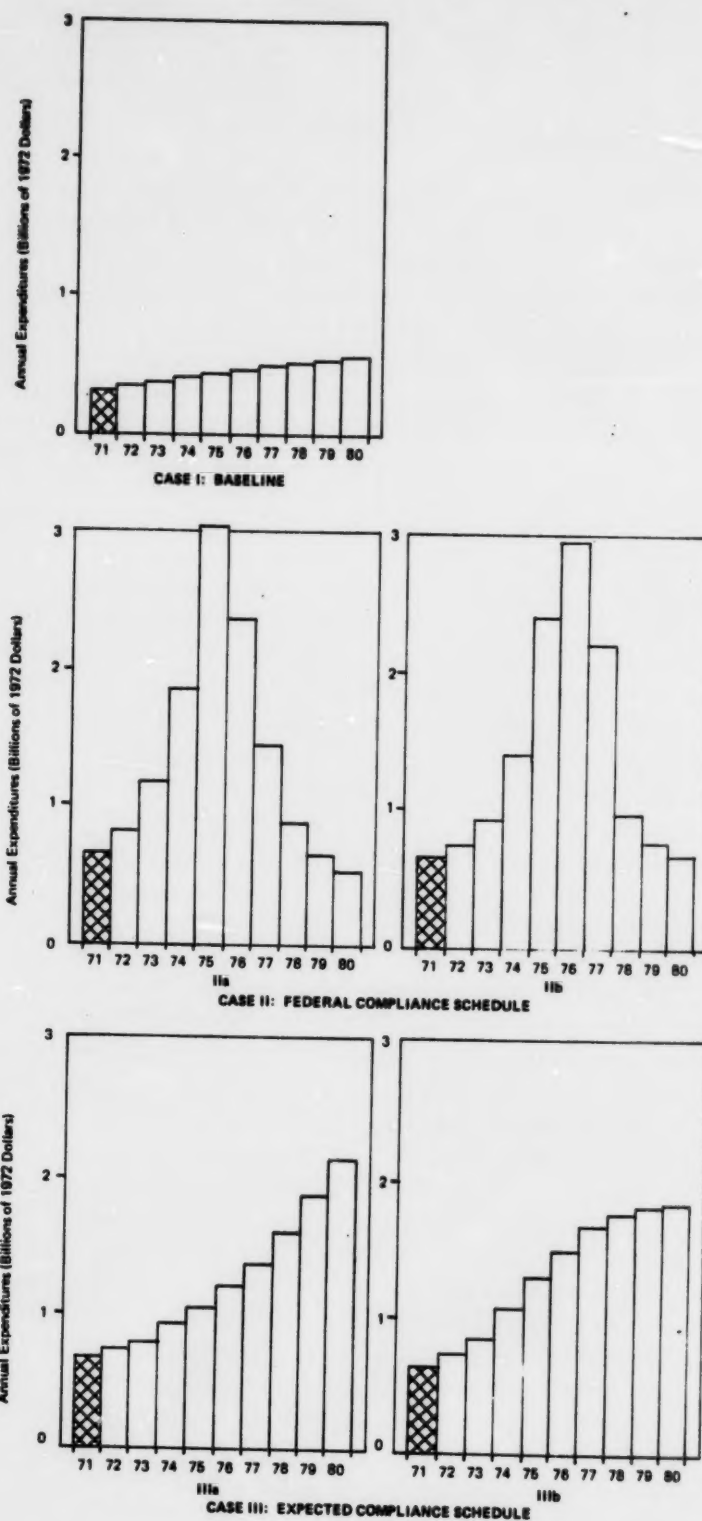
6. Comparative Expenditures

A comparative discussion of the three cases may be focused around Figure II-2 which shows total expenditures for each case over the period 1972-80.

It is initially evident that environmental legislation has done much to "create" an air pollution control equipment market since 1963. Assuming the purchasing incentive of industry would not exceed their rate of industrial plant investment, our estimated baseline equipment demand of \$114 million in 1971 is but 41% of the actual equipment demand within that year. Interestingly enough, should baseline equipment demand have continued to grow at our estimated rate of 5.4%/year, its 1980 volume of \$183 million would still remain below the \$243 million estimated to have been already shipped by 1971.

The baseline case also indicates that the dust collection business would have remained essentially a particulate control activity. Based on 1963 estimates, gaseous control equipment accounted for but 9% of total equipment volume in any given year. Gaseous control sales would probably have remained dominated by direct flame and other incineration hardware, whose major market was fume and odor control.

Case II indicates that equipment manufacturers may yet experience an overall growth of 33%/year (Case IIa) to 45%/year (Case IIb) in demand prior to 1975, should federal and state governments rigidly enforce the 1975-targeted deadline. Referring to our previous comments, the maximum estimated demand for equipment in 1975 (\$1,087 million (IIa) or \$758 million (IIb)) might easily have been twice that amount had not EPA granted waivers on several State Implementation Plans. The relatively high estimates of \$773 or \$745



Source: Arthur D. Little, Inc. estimates.

FIGURE II-2 AIR POLLUTION CONTROL COMPARATIVE EXPENDITURES, 1972-80

million in 1976, and \$433 or \$532 million in 1977, may be attributed in large part to this carry-over demand.

Note also in both Case IIa and Case IIb that the mix between particulate and gaseous control equipment changes dramatically beginning in 1976. The need to prove gaseous control technology before serious orders can be made has the effect of carrying the backlog of gaseous demand into the latter five years of the decade. Whereas gaseous control equipment accounted for 14% of total equipment in 1975, it may account for 45% of the market in 1980 under Case IIa. Under a more optimistic assumption on the availability of adequate SO₂ removal systems, Case IIb shows gaseous control hardware to be 34% of total equipment demand in 1975, and subsequently, 54% of total equipment in 1980.

The major implication of Case II is the absence of a healthy and ongoing APC business following the needed surge in production capacity between 1972 and 1975. Our estimates show a Case IIa market of \$142 million and a Case IIb market of \$174 million in 1980, representing a market decrease of 87% within five years. Theoretically, the market would regain a positive growth rate during the 1980's, tied to a new source market and to any further legislative targets.

Case III reflects the more common growth of a maturing market. Building to an annual growth in demand of 12% (Case IIIa) and 15% (Case IIIb) prior to 1975. This is a more desirable future from the point of view of equipment manufacturers, and possibly, on balance, for the purposes of insuring a healthy national capability to continue to handle pollution.

The major differences between Cases IIIa and IIIb is the demand for equipment over the period 1975-80. In Case IIIa, particulate control equipment demand over this period is sustained by customers in the power generating sector (average growth: 8.7%/year), and by the emerging growth of gaseous control equipment (average growth: 24.3%/year). However, in Case IIIb, the assumption of an adequate gaseous control technology available over the period 1972-75 and the consequent larger demand for these systems results in a continuing growth throughout the decade in gaseous control. This, together with the falling demand for particulate equipment (average decrease: 24.9%/year) results in a fairly level market for all equipment (above \$400 million annually) following 1975. In summary, the average annual growth for APC equipment in Case IIIa is 12.3% over the period 1975-80, while Case IIIb shows a market growth of -0.2% over the same period.

While the demand shown for Case III in Figure II-2 assumes legislative pressure will continue, the cumulative effect of this demand schedule would expire estimated cumulative needs shortly after 1980. The market would then return to a demand based upon new source construction, or upon new legislative targets. It is clear, however, that a decrease to a new-source level of demand from the maximum expenditures of Case III is less drastic than from the peak of expenditures in Case II.

C. MUNICIPAL SEWAGE TREATMENT

Municipal sewage treatment expenditures were subdivided into three categories as follows:

1) Treatment Plant Proper

Otherwise described as "inside the fence" construction. Refers to terminal treatment and does not include any municipal collection systems.

2) Ancillary Facilities

Defined to include interceptors, outfalls, and pumping stations, for those facilities which are auxiliary to the treatment plant proper in terms of transferring effluent from the municipal collection networks.

3) Collection Systems

Includes trunk sewers, force mains, and similar collection systems which commonly empty into interceptors.

These separate categories are consistent with the form of published information from both DOC and EPA – the two most reliable sources reporting activities within this field. EPA's statutory definition of a sewage treatment plant differs from DOC's definition in that only "inside the fence" construction and ancillary facilities are considered by EPA.⁸

In terms of this study, the specialty equipment and instrumentation of greatest concern to us are generally considered as part of the treatment plant proper. The type and size of specialty equipment used within any given project will depend upon, among others, the effluent characteristics, volume flows, system capacity, and level of treatment desired.

Compared to the six or so major product types within the air pollution control field, the list of major wastewater treatment equipment items is quite lengthy. We have defined specialty equipment to include the following:⁹

- Aerators
- Chemical Feeders
- Chlorinators
- Degritters
- Dewatering
- Digestion
- Filter Underdrains
- Ion Exchange Units
- Mixers
- Pressurized Flotation

⁸EPA's responsibilities for making federal grants for municipal construction do not extend to the collection systems. Grants for collection systems (sewers) are available from agencies in the Departments of Housing and Urban Development, Agriculture, and Commerce.

⁹A short description of the major types of specialty equipment and instrumentation used in wastewater treatment is included in Table B-1, Appendix B.

Pumps
Screens, Disintegrators
Sedimentation
Package Pumping Stations
Package Treatment Plants

The instrumentation associated with municipal sewage treatment was assumed to include the following:

Filter Rate Control
Filter Gauges
Meters and Controls
Water Quality Monitoring

Due to the lengthy list of specialty equipment and instrumentation, our estimates of the annual demand for each product type under each of the three scenarios are presented in Appendix B – separate from tables in this chapter showing our general estimates of annual expenditures.

1. Past Activity

The most reliable information on the shipments of specialty equipment used within this sector originates almost entirely from the Department of Commerce. As the result of surveys of shipments in 1965, 1968, and 1970, a good data base is available, which gives equipment shipments by both end use – water or wastewater treatment – and purchasing sector – municipal or industrial. Although we question the use of the DOC information as a basis for gauging trends in specific equipment usage, we do accept it as a satisfactory indicator of the relative product mix needed for this analysis.

A source of statistics from a trade source similar to IGC does not exist for water pollution control. The Water Pollution Control Federation (WPCF) is a technical organization whose individual members are concerned mainly with the construction, operation, and management of treatment systems. WPCF neither collects nor publishes information on specialty equipment shipments other than reprinting those publications originating from DOC and other government agencies. Limited information on annual shipment of some product types is available through the Process Equipment Manufacturers' Association (PEMA). That information is of limited use in that it covers only PEMA members (a fraction of the total companies within this field) and makes no distinction as to end use markets – wastewater treatment, water treatment, or otherwise. The Water and Wastewater Equipment Manufacturers Association (WWEMA) is another group which does not collect product-specific or demand data – data which would be invaluable to this kind of public policy analysis.

Table II-9 details our estimates of annual expenditures for municipal sewage treatment for the period 1965 to 1971. For the most part, these estimates (in current dollars) are

TABLE II-9
MUNICIPAL SEWAGE TREATMENT
CONSTRUCTION PUT-IN-PLACE, 1965-71
(Millions of Current Dollars)

	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>
Treatment Plant Proper ^a							
Specialty Equipment	51	59	50	75	67	83	106
Instrumentation ^b	<u>6</u>	<u>6</u>	<u>6</u>	<u>7</u>	<u>7</u>	<u>12</u>	<u>16</u>
Subtotal	57	65	56	82	74	95	122
Associated Construction	<u>373</u>	<u>412</u>	<u>336</u>	<u>488</u>	<u>423</u>	<u>491</u>	<u>613</u>
Total	430	477	392	570	497	586	735
Ancillary Facilities ^c	507	556	457	658	579	618	774
Collection/Distribution Systems ^d	<u>363</u>	<u>399</u>	<u>328</u>	<u>472</u>	<u>415</u>	<u>443</u>	<u>556</u>
GRAND TOTAL	1300	1432	1177	1700	1491	1647	2065

^aOtherwise described as "inside the fence" construction.

^bIncludes flow rate control, water quality monitoring, meters, remote and automatic controls.

^cIncludes interceptors, outfalls, and pumping stations.

^dIncludes sewers, force mains, and similar collection systems.

SOURCE: Department of Commerce, Arthur D. Little, Inc. estimates

based upon various DOC publications. Following their recommendation, we accepted actual construction put-in-place (not appropriated expenditures) as the most accurate measure of activity within this field.

To better judge historical construction activity, it is useful to convert these previous expenditures to constant (1957-59 in this case) dollars. Table B-5 shows constant dollar equivalents¹⁰ of total construction put-in-place over the period 1958 through 1971. On this basis, average annual growth since 1965 has fallen considerably (to 0.6%/year) from the growth (7.6%/year) experienced over the period 1958-1965. This phenomenon may be traced in large part to the hesitancy of municipalities to pursue wholly self-financed facilities in the face of promised federal assistance. Since federal assistance did not meet these expectations from 1966-1971, municipalities continue to wait. Present indications are that the construction of sewage treatment facilities are now, finally, on the upswing.

2. Demand Estimates

Our estimates of the total investment required to upgrade municipal sewage treatment to equivalent secondary treatment by 1980 were based in large part upon a December 1971 EPA survey of municipal needs. The results of this survey are contained within the 1972 *Economics of Clean Water*, EPA's Annual Report to Congress on the status of water pollution abatement.

The results of the published EPA survey were adjusted upward to account for the following:

- 1) The municipalities surveyed covered only those serving more than 10,000 population. A proportional adjustment was made to account for total domestic population.
- 2) A slight upward adjustment was made to offset EPA's estimated coverage of 95.5%.
- 3) Municipalities were instructed to include only those needs for the period 1972-76. An adjustment forecast was made to extend their needs through 1980.
- 4) Conversion from 1971 to 1972 dollars.

Table B-6 summarizes our estimates of required capital investment estimates, 1972-80, by type of construction and treatment level. The total estimated investment found there (\$19.46 billion) covers only that construction related to treatment plant proper and ancillary facilities, and omits any estimates for collection systems.

Collection systems were reported to account for approximately 28% of annual municipal sewage treatment plant construction according to a 1965-66 survey (the last such survey)

¹⁰Conversion to constant dollars was made using the Sewage Treatment Plant Construction Cost Index available through the Treatment Optimization Research Program, EPA, Cincinnati, Ohio.

published in April, 1966, in *Water and Wastes Engineering*. Assuming that proportion of annual construction expenditures which are collection systems will remain approximately constant, an additional \$7.57 billion may be added to the \$19.46 billion of Table B-6 to equal a cumulative estimate of \$27.03 billion for the period 1972-80. This is shown in Table II-10.

Table II-10 also indicates a shift in the distribution of annual sewage treatment expenditures. The average distribution of annual expenditures within the period 1968 to 1970 includes 34% for construction of the treatment plant proper and 38% for ancillary facilities. Were these percentage distributions projected to the year 1980 from the trends in the 1965-1970 DOC data, a 40%-20% breakdown for treatment plant proper and ancillary facilities would have resulted. However, an investigation of the EPA needs survey indicates municipalities are anticipating even greater expenditures for the treatment plant proper portion than indicated by the trends.¹¹ Based on the survey, 42.5% of estimated needed investment will go to inside-the-fence construction over the period 1972-80. Inasmuch as this is an average over the period, the treatment plant share must exceed 42.5% by 1980 — in a manner like the 1980 distribution shown in Table II-10.

A review of Table B-6 shows that municipalities anticipate having to spend a disproportionate amount for increases in both plant capacity and treatment level for secondary and tertiary processes. This is a result of continued pressures to upgrade the level of all treatment beyond the primary stage. Hence, we note that 63% of the planned expenditures for secondary treatment and 69% of those for tertiary treatment will be diverted to increases in capacity, treatment level, or both.

In summary, our required investment estimate of \$27.03 billion correlates rather closely with the estimates contained within *The Third Annual Report of the Council on Environmental Quality* (August, 1972). In addition, we are in agreement with recent DOC estimates as reported within a paper given to the National Symposium on the Costs of Water Pollution Control.¹²

3. Case I: Baseline

We selected 1965 as the baseline year in municipal wastewater treatment to coincide with the passage of the Water Quality Act (1965) and the Clean Water Restoration Act (1966) which substantially increased the federal subsidies available to municipalities for sewage treatment facilities.

As in air pollution control, three inputs were required to develop a hypothetical baseline case: 1) total equipment shipments in 1965; 2) market growth, 1965-1980; and 3) the annual breakdown of shipments by product type.

¹¹It is possible the EPA survey results underestimate the required investment for ancillary facilities, particularly in the face of an emerging trend toward regional wastewater treatment schemes. Our annual expenditure scenarios remain based on the \$7.49 billion estimate of Table II-10. It is also uncertain whether the EPA survey of needs included construction presently under way. If not, another 3-5 billion would be added to the \$27 billion in Table B-6.

¹²"The Present and Coming Market for Pollution Control Equipment," K.L. Kollar and R. Brewer, Office of Business Research and Analysis, Bureau of Domestic Commerce, Department of Commerce, April, 1972.

TABLE II-10

MUNICIPAL SEWAGE TREATMENT

REQUIRED CONSTRUCTION EXPENDITURES, 1972-80^a

	Distribution of Annual Expenditures (Percent)			Cumulative Expenditures 1972-80 (Millions of 1972 Dollars)
	Recent Historical 1968-70	Projected Historical 1980	Expected 1980	
Treatment Plant Proper ^b				
Specialty Equipment Instrumentation ^c	4.7 <u>0.6</u>	6.5 <u>1.0</u>	7.6 <u>1.8</u>	\$ 1,862 <u>373</u>
Subtotal	5.3	7.5	9.4	2,235
Associated Construction	<u>28.7</u>	<u>32.5</u>	<u>37.6</u>	<u>9,735</u>
TOTAL	34.0	40.0	47.0	11,970 ^f
Ancillary Facilities ^d	38.0	32.0	25.0	7,490 ^f
Collection/Distribution Systems ^e	<u>28.0^g</u>	<u>28.0^g</u>	<u>28.0^g</u>	<u>7,570</u>
GRAND TOTAL	100.0	100.0	100.0	\$27,030

^aReflects construction put-in-place; movement towards secondary/tertiary treatment.^bOtherwise described as "inside the fence" construction.^cIncludes flow rate control, water quality monitoring, meters, remote and automatic controls.^dIncludes interceptors, outfalls, and pumping stations.^eIncludes trunk sewers, force mains, and similar collection systems.^fBased on December 1971 EPA survey and previous ADL estimates.^gBased on survey of budgeted expenditures for 157 wastewater disposal projects, Water and Wastes Engineering, April 1966.

SOURCE: Department of Commerce, Arthur D. Little, Inc. estimates

Total equipment shipments (and total construction expenditures), expressed in current dollars, were available through the Department of Commerce.

Growth in annual expenditures over the period 1966 to 1980 were determined by applying a multiplier incorporating the three variables, which, in our opinion, best relate to a hypothetical baseline activity in wastewater treatment plant construction. The variables chosen to devise this annual growth index were: 1) growth in U.S. domestic population; 2) growth in per capita municipal (water supply) withdrawal; and 3) growth in the proportion of population served by municipal sewerage systems. These variables, their growth rates, and the combined multiplier indices are shown in Table B-7 for five-year intervals over the period 1965-80. In summary, these factors combine to give annual multipliers of 1.043 between 1970-75 and 1.050 between 1975-80.

The distribution of annual equipment shipments by product line was assumed equal to the percentage distribution in 1965, as reported by DOC. As in air pollution, we assumed that the incentive to select an alternative treatment system originates in large part upon the enforcement of a higher level of treatment through federal legislation.

Estimated annual expenditures for the baseline case are shown in Table II-11, and are backed up by estimated annual shipments by product type in Table B-8.

4. Case II: Federal Compliance Schedule

A strict schedule of the annual expenditures required to meet federal legislation by the year 1976 would have shown maximum annual demand in that year, a growth rate exceeding 50%/year beginning in 1973, and a level of demand in 1976 approximately equal to the growth in national domestic population. The estimated annual expenditures and equipment shipments shown in Table II-12 and Table B-9 have been adjusted downward slightly to account for a response time in municipal construction (3-5 years) which differentiates it from the response time of the industrial sector. Were these expenditures being made by the private sector, peak annual expenditures in 1976 and growth rates prior to that time would have been greater.

5. Case III: Expected Compliance Schedule

Both the legislatively-supported trend towards greater treatment and the availability of reasonable (economically) treatment technology will insure a continued growth in WPC expenditures. The recent dampened growth of annual investment could continue until late 1973, at which time accelerated growth should carry the market to the end of the decade.

A growth in the percentage of annual expenditures which accounts for the treatment plant proper should begin in 1974 and continue until 1980, at which time, as indicated by the needs survey, treatment plant construction would approximate half of total annual expenditures (including collection system).

As in air pollution hardware, we expect the equipment mix to change. Variations in treatment technology and economics plus an increased trend towards advance treatment will affect individual product fortunes. For our prediction of emerging equipment trends, Table B-10 in Appendix B was compiled. The percentage of annual sales attributed to each

TABLE II-11

CASE I: BASELINE

MUNICIPAL SEWAGE TREATMENT

ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditures (Millions of 1972 Dollars)										Growth (%/year) ^b	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Treatment Plant Proper: ^c												
Specialty Equipment	96	100	104	109	114	119	125	132	138	145		
Instrumentation ^d	11	12	12	13	13	14	15	15	16	17		
Total Equipment	107	112	116	122	127	133	140	147	154	162		
Associated Construction	703	733	765	797	832	874	917	963	1011	1062		
TOTAL	810	845	881	919	959	1007	1057	1110	1165	1224		
Ancillary Facilities ^e	956	996	1040	1084	1130	1187	1246	1309	1375	1443		
Collection/Distribution Systems ^f	684	714	744	776	810	850	893	937	984	1033		
GRAND TOTAL	2450	2555	2665	2779	2899	3044	3196	3356	3524	3700	4.3	5

^aReflects construction put-in-place.^bBased on growth multiplier, see previous table.^cOtherwise described as "inside the fence" construction.^dIncludes flow rate control, water quality monitoring, meters, remote and automatic controls.^eIncludes interceptors, outfalls, and pumping stations.^fIncludes trunk sewers, force mains, and similar collection systems.

SOURCE: Arthur D. Little, Inc. estimates.

TABLE II-12

CASE II: FEDERAL COMPLIANCE SCHEDULE

MUNICIPAL SEWAGE TREATMENT

ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditures (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Treatment Plant Proper ^b												
Specialty Equipment Instrumentation ^c	110 17	126 21	159 28	221 39	292 54	368 78	300 65	211 52	113 23	73 15	27.6 33.0	-24.4 -23.0
Total Equipment	127	147	187	260	346	446	365	263	136	88	28.4	-24.1
Associated Construction	631	727	905	1090	1394	1763	1567	1189	662	432	21.9	-21.0
TOTAL	758	874	1092	1350	1740	2209	1932	1452	798	520	23.1	-21.5
Ancillary Facilities ^d	798	782	780	810	926	1175	1092	924	570	416	3.8	-14.8
Collection/Distribution Systems ^e	574	644	728	840	1037	1316	1176	924	532	364	15.6	-18.9
GRAND TOTAL	2130	2300	2600	3000	3703	4700	4200	3300	1900	1300	14.8	-18.9

^aReflects construction put-in-place.^bOtherwise described as "inside the fence" construction.^cIncludes flow rate control, water quality monitoring, meters, remote and automatic controls.^dIncludes interceptors, outfalls, and pumping stations.^eIncludes trunk sewers, force mains, and similar collection systems.

SOURCE: Arthur D. Little, Inc. estimates.

previously listed major product type are given – assuming total equipment sales in future years may be explained within the product categories listed. The 1970 breakdown was derived from a Department of Commerce publication while the subsequent estimates are our own and are based on the following:

- 1) recent trends in annual sales by each product type (DOC data);
- 2) our perception of the trade-offs which will be made between particular equipment and treatment systems; and
- 3) the opinions of selected industrial contacts concerning the trade-offs which will be made between particular equipment and treatment systems.

Once total markets in Case III were estimated in Table II-13, the estimates of specific product demands were calculated for Table B-11.

6. Comparative Expenditures

This discussion of the annual demand schedules presented by Cases I, II, and III are made with reference to Figure II-3.

Assuming annual expenditures for municipal sewage treatment would have grown according to the reasonable growth index we derived (Table B-7), the 1971 baseline expenditure estimate of \$2450 million would have exceeded (by approximately 15%) our \$2130 million estimate of actual expenditures during that year. This situation contrasts decidedly from the air pollution control analysis where baseline expenditures during the 1970's were consistently below both Case II and Case III estimates.

The differences between the APC (Figure II-2) and municipal sewage treatment scenarios (Figure II-3) may be explained partly by customer differences. The air pollution control market is predominately one of industrial customers. Industrial investments which will not positively affect profits are best brought about by legislative enforcement. However, when those pressures are brought to bear, industrial expenditures for pollution control are more responsive than in the public sector. Secondly, the pressure on industry concerning air pollution control during the mid- and late-1960's was significantly greater than it had been previously. Industry had little choice in increasing expenditures for air pollution control equipment beyond the historical growth rate of the "dust collection business". This was not the case for municipalities; indeed, almost the opposite took place.

Federal legislation had made funds available for sewage treatment construction, and there is clear evidence that most municipalities, in anticipation of federal assistance, understandably postponed sewage treatment projects. The result was a downturn in the growth of municipal expenditures. Only recently has there been some indication that the dampened municipal market is beginning to show accelerated growth. This recent trend corresponds to a similar acceleration of obligated funds for this purpose from EPA.

Whereas the baseline expenditures are initially greater, rigid enforcement pressure, such as

TABLE II-13

CASE III: EXPECTED COMPLIANCE SCHEDULE

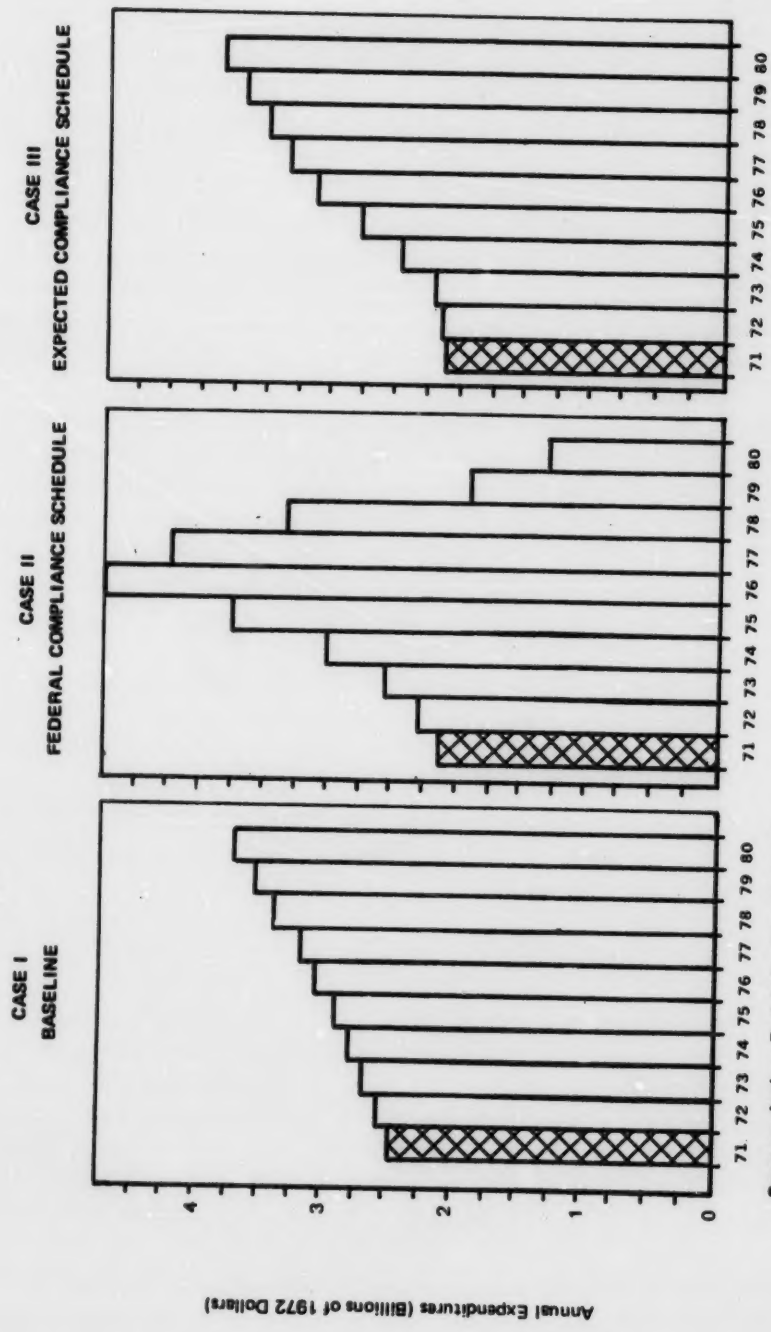
MUNICIPAL SEWAGE TREATMENT

ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditures (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Treatment Plant Proper ^b												
Specialty Equipment Instrumentation ^c	110 17	114 19	123 21	152 26	186 33	222 42	239 48	255 54	277 62	293 69	14.1 17.9	9.5 15.9
Total Equipment	127	133	144	178	219	264	287	309	339	362	14.6	10.6
Associated Construction	631	659	696	835	1000	1171	1240	1301	1391	1448	12.2	7.7
TOTAL	758	792	840	1013	1219	1435	1527	1610	1730	1810	12.6	8.2
Ancillary Facilities ^d	798	749	751	765	776	811	863	910	920	961	- 0.7	4.4
Collection/Distribution Systems ^e	574	599	619	692	776	874	930	980	1030	1078	7.8	6.8
GRAND TOTAL	2130	2140	2210	2470	2771	3120	3320	3500	3680	3851	6.8	6.8

^aReflects construction put-in-place.^bOtherwise described as "inside the fence" construction.^cIncludes flow rate control, water quality monitoring, meters remote and automatic controls.^dIncludes interceptors, outfalls, and pumping stations.^eIncludes trunk sewers, force mains, and similar collection systems.

SOURCE: Arthur D. Little, Inc. estimates.



Source: Arthur D. Little, Inc. estimates.

FIGURE II-3 MUNICIPAL SEWAGE TREATMENT
COMPARATIVE EXPENDITURES, 1972-80

that assumed in Case II, creates an accelerated expenditure program that overtakes the baseline around 1973-74. In addition, an enforced federal compliance schedule would bring about not only increased growth of total expenditures, but an additional growth in the percentage of total expenditures used for construction of the treatment plant proper. Equipment demand in Case II is estimated to increase at an average rate of 28%/year (constant 1972 dollars) over the period 1971-75 versus a rate of approximately 15%/year for total expenditures. In the baseline case, expenditures for specialty equipment would have been less in the absence of environmental legislation. Table B-12 shows a cumulative value of equipment shipments for Cases II and III of \$2235 million over the period 1972-80 – substantially higher than cumulative equipment shipments for the baseline case.

As in air pollution control, an enforcement of the federal compliance schedule eventually creates a declining equipment market, in this case beginning in 1977. The municipal sewage market does not fall as quickly as for APC; nonetheless, an average annual negative growth of 24%/year (1975-80) in Case II would promise severe problems for the WPC equipment industry.

In comparison to Case II, Case III shows a steadier long-term growth rate of 6.8%/year. Under our demand estimates, this growth rate may be sustained through 1980 without exhausting the backlog of potential needs. We show a pick-up in annual expenditures in 1974 and an acceleration in the growth rate until 1976. This short-term acceleration of expenditures is identical in cause – the federal deadlines – to a similar effect shown previously in Case III of air pollution control, although the municipalities' response is less volatile. After 1980, however, demand would fall off in Case III as well, unless further requirements are enforced.

The growth in equipment demand in Case III again exceeds the growth of total annual expenditures. Equipment shipments average 14.6%/year growth from 1971-75, and 10.6%/year growth from 1975-80, compared to a growth in total expenditures of 6.8%/year.

While the cumulative demand of expenditures for both Cases II and III are roughly equivalent over the period 1972-80 a constantly increasing market to the 1980 peak of \$3851 million in Case III is more desirable from an industry standpoint than a declining market after the \$4700 million peak in Case II.

D. INDUSTRIAL WASTEWATER TREATMENT

Reliable information concerning annual expenditures in industrial wastewater treatment facilities is so scarce that an attempt to sub-divide any reported data into separate construction categories could be carried out under only a rough set of assumptions. There is nothing available which even approaches the credibility of the two separate data sources which facilitated our division of expenditures within the municipal sewage treatment sector. At best we are able to break out estimated demand for specialty equipment and instrumentation and refer to the supporting equipment and physical plant as "associated construction".

This simplistic approach becomes more comfortable when one considers the character of industrial treatment facilities. The vast collection systems common in municipal sewage construction generally have no counterpart within industrial facilities. Geographically-large

interceptor systems and outfalls are likewise also missing. Therefore, the industrial plant treatment facility may be assumed to be most similar to our previous definition of "inside the fence" construction. Thus, the annual expenditure estimates shown within this section are representative of treatment plant proper construction only.

The lines of specialty equipment and instrumentation supplied to the industrial sector for use in wastewater treatment are similar to the hardware utilized in municipal sewage treatment. Detailed demand estimates will therefore be presented in terms of the product types used in the previous section. As before, our estimates of demand by type of hardware is included within Appendix B and is separate from our estimates of expenditures.

1. Past Activity

The DOC surveys of 1965, 1968, and 1970, are again the basis for estimates regarding equipment shipments for industrial water pollution control. The DOC data on equipment shipments to the industrial sector is not presumed to be as representative as its data on sewage plant construction. DOC estimates that 95% of the equipment sales to municipalities are covered, but that only 70% of the equipment purchases by industry is picked up in the surveys.¹³

Table II-14 shows our estimates of the annual value of construction put-in-place for industrial wastewater facilities. These are primarily based upon the DOC figures. The specialty equipment and instrumentation data has been adjusted upward to account for DOC's estimates of market coverage.

Another alternate source reporting industry's investment for water (and air) pollution control are the annual McGraw-Hill surveys. First released in 1968, the surveys summarize total reported expenditures for air and water pollution control, the percentage of capital spending this expenditure represents, and industry's estimate of the cost of bringing existing facilities up to present control standards.

For the purposes of this study, we chose not to use McGraw-Hill figures due to fact that those reported expenditures for air and water pollution control are not sufficiently detailed to be of use in determining past or planned expenditures for equipment. Secondly, the self-serving incentive for industry to report somewhat inflated expenditures must be considered a serious limitation of these surveys.

2. Demand Estimates

Unlike municipal sewage treatment facilities which are centralized, industrial wastewater treatment may take place at several points during a manufacturing process. This lends complexity to the estimation of treatment costs across industries which differ greatly in process flows and production volumes.

¹³The majority of manufacturers responding were municipally-oriented. Consequently, process equipment manufacturers, who produce recirculation and waste reclamation equipment, were not as well represented.

TABLE II-14
INDUSTRIAL WASTEWATER TREATMENT
CONSTRUCTION PUT-IN-PLACE, 1965-71
(Millions of Current Dollars)

	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>
Specialty Equipment	29	34	41	51	78	118	167
Instrumentation ^a	<u>7</u>	<u>7</u>	<u>8</u>	<u>8</u>	<u>11</u>	<u>17</u>	<u>25</u>
Subtotal	36	41	49	59	89	135	192
Associated Construction ^b	<u>189</u>	<u>219</u>	<u>271</u>	<u>341</u>	<u>471</u>	<u>665</u>	<u>948</u>
TOTAL	225	260	320	400	560	800	1140

^aIncludes flow rate control, water quality monitoring, meters, remote and automatic control.

^bIncludes all in-plant auxiliary systems.

SOURCE: Department of Commerce, Arthur D. Little, Inc. estimates.

Our estimates of the total investment were derived somewhat differently than in the previous cases of air pollution control (individual industry methodology studies) and municipal sewage treatment (modified municipal needs survey). Using 1968 as a base year, we estimated the total cost of control for *all* existing domestic manufacturing. From this we subtracted estimates of industrial investment made through 1968, and annually over this period 1969 to 1971. Allowing for the construction of new industrial production facilities, the remainder represents the capital investment required, 1972-80.

With only slight modifications concerning treatment economics, this is essentially the same approach taken in the *1972 Economics of Clean Water* — one which generally assumed a target of secondary treatment.

First, an estimate of the total cost required to control all manufacturing facilities as of 1968 was calculated using the individual industry cost models presented in the *1972 Economics of Clean Water*, Volume II. Typical manufacturing units were defined for each of the approximately 75 three- and four-digit SIC industries using the plant inventories and estimates of annual water demands available from the *1967 Census of Manufactures* (Department of Commerce). The cost model for each unit was different to account for variations in water consumption, discharge characteristics, and effluent loadings. An estimate of capital investment was given for one or more of the following processes with each sub-industry, the total of which represented the cost of control for a unit within that sub-industry:

- Oil Separation
- Equalization
- Coagulation & Separation
- Neutralization
- Flotation
- Sedimentation
- Aeration
- Biological Stabilization
- Chlorination
- Evaporation
- Incineration
- Activated Sludge

To account for industry growth over the period 1968 through 1980 in terms of plant-units, a growth index was developed for each industry. This index (the "water productivity growth index") is based upon the historical growth of manufacturing *and* the change in water usage efficiency within each industry over the period 1959 (or 1964) to 1968. In so doing, we assumed that the cost of industrial wastewater treatment will entice industry to make better use of its water in the future. Therefore, the growth in demand for wastewater facilities is more closely associated with the increase of water productivity than with the growth of manufacturing output as a whole.

The unit plant treatment costs were given in terms of 1968 utilization efficiencies. Agreeing with the assumptions made in the *Economics of Clean Water*, we related these treatment costs to a "median efficiency" case by applying the ratio of the "median

efficiency" costs to the "1968 utilization efficiency" to the model plant treatment costs for each of the major two-digit SIC industries. In addition, we assumed the median efficiency costs would hold for all retrofit construction on facilities in place as of 1968, and on all new construction up to and including 1975. For new construction during the period 1976-1980, we assumed a "most efficient third" treatment cost, and likewise readjusted the unit plant treatment costs. These adjustments were made in an attempt to allow for a decrease in treatment economics due to an increase in technology.

Table B-13 (Appendix B) summarizes our estimates of the capital investment required for water pollution abatement for both existing plants in 1968 and new plants, 1968-1980. The "water productivity growth factor" discussed above is also given for each sub-industry.

Having developed a total required capital investment estimate (in constant 1972 dollars), past investment must be subtracted from this total to identify that investment required from 1972 through 1980. This is shown in Table II-15. It should be noted that the \$15.20 billion estimate indicated in Table B-13 was adjusted upward to \$15.96 billion (Table II-15) under an assumption that our estimates of selected industry needs account for about 95% of total industrial requirements.

The estimates of industry-supplied and publicly-supplied treatment through 1968 were found in the *Economics of Clean Water*. The estimate of \$958 million attributed to publicly-supplied treatment is based upon an assumption of equivalent service, e.g., the cost of wastewater treatment is the same in all cases, without regard to who supplies the treatment. Also shown are estimated industry expenditures for 1969, 1970, and 1971. These are based upon our estimates of actual construction activity previously given in Table II-14.¹⁴

Table II-15 indicates that approximately 22% of required wastewater treatment facilities were in place through 1968, and that an additional 17% has been installed by industry since then. Using these figures, approximately 61% of the total cost of wastewater treatment facilities remains to be installed by industry to meet federal standards prior to 1980.

3. Case I: Baselines

As in municipal sewage treatment, 1965 was selected as the base year to coincide with the passing of the Water Quality Act. The baseline case was constructed using: (1) the adjusted total of equipment shipments reported by DOC in 1965; (2) the growth index developed to measure industrial plant investment for the APC analysis (Table B-14); and (3) the breakdown of equipment by product type, also given by DOC in 1965. These estimates are shown in Table II-16, and our estimates by product line are given in Table B-15.

¹⁴For lack of a better deflator, conversion to constant 1972 dollars was accomplished using the Sewage Treatment Plant Construction Cost Index used in the previous section on municipal sewage treatment construction.

TABLE II-15

INDUSTRIAL WASTEWATER TREATMENT
REQUIRED CONSTRUCTION EXPENDITURES, 1972-80
(Millions of 1972 Dollars)

	<u>Cumulative Expenditures</u>	<u>Distribution (Percent)</u>
CUMULATIVE REQUIRED EXPENDITURES		
Plants in Place, 1968:	11,483 ^a	
Industrial Growth, 1968-80:	<u>4,482^a</u>	
Total	15,965	100
PAST EXPENDITURES		
Industry-Supplied Treatment, through 1968:	2,502	16
Publicly-Supplied Treatment, through 1968: ^b	958	6
Industry Expenditures, 1969:	706	4
1970:	931	6
1971:	<u>1,176</u>	<u>7</u>
Total	<u>6,271</u>	<u>39</u>
REQUIRED EXPENDITURES, 1972-80	9,694	61

^a Adjusted upward under assumption that previous estimates of required expenditures in those industries studied accounted for approximately 95% of total required expenditures.

^b Based on the assumption of equivalent service, e.g., the value of wastewater treatment is the same in all cases, without regard to who supplies the treatment.

SOURCE: Environmental Protection Agency; Department of Commerce; Arthur D. Little, Inc. estimates.

TABLE II-16

CASE I: BASELINE

INDUSTRIAL WASTEWATER TREATMENT
ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditures (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Specialty Equipment	56	59	63	66	69	73	77	81	86	91		
Instrumentation ^b	13	14	14	15	16	17	18	19	20	21		
Subtotal	69	73	77	81	85	90	95	100	106	112		
Associated Construction	365	384	405	427	450	474	500	527	555	584		
TOTAL	434	457	482	508	535	564	595	627	661	696	5.4	5.4

^aReflects construction put-in-place.^bIncludes flow rate control, water quality monitoring, meters, remote and automatic control.

SOURCE: Arthur D. Little, Inc. estimates.

4. Case II: Federal Compliance Schedule

Tables II-17 and B-16 show the annual expenditures and equipment shipments required to approach federal standards by the year 1976. In developing the curve we have shown maximum expenditures (\$1585 million) to occur in 1976, and have carried a minimum of investment backlog beyond 1977. This reflects the faster response time of industry when compared to municipalities under the same pressures of compliance deadlines. Note also that the average annual growth rate of 7.2%/year required to approach maximum expenditure by 1976 is substantially less than our estimate of recent construction activity (Table II-14) within the industrial sector.

5. Case III: Expected Compliance Schedule

This alternative future assumes that industrial compliance to standards will be delayed and that the annual growth rate of expenditures would be less than in Case II. With growth of slightly over 4%/year, maximum expenditures peak at \$1395 million in 1976, as shown in Table II-18.

As in the air pollution control and municipal sewage treatment sectors, we adjusted the percentage of annual expenditures attributed to specialty equipment upward to account for the trend toward advanced wastewater treatment.

As before, we also forecasted trends in equipment mix over the period 1972-1980 to allow for advancements in treatment technology and requirements. Those forecasts are shown in Table B-17.

Table II-18 and Table B-18 present our estimated annual expenditures and associated equipment shipments respectively.

6. Comparative Expenditures

Figure II-4 compares the annual demand schedules presented by the three alternative futures. Under the assumption that the annual expenditures for wastewater treatment would have grown at a rate which approximated the growth in industrial plant investment, Figure II-4 verifies that federal legislation was effective in creating both a construction and specialty equipment market. The estimated 1971 baseline expenditure of \$434 million is but 35% of our estimated \$1176 million for actual expenditures in that year. This was not the case in municipal sewage treatment where our projected baseline exceeded actual expenditures for 1971.

Notice also that only in Case I does the year-to-year growth in expenditures remain positive throughout the decade. In Case II, we have simulated an expenditure pattern which is indicative of industry's relatively fast response time. As in air pollution control, expenditures in the years following the announced deadline fell sharply. In this instance, the 1976 expenditure of \$1585 million drops to \$950 million in 1977 — a decrease of 40%.

We believe the incremental growths shown in Case II may progressively decrease in the period approaching 1976, the implied deadline. This may occur in large part due to a

TABLE II-17

CASE II: FEDERAL COMPLIANCE SCHEDULE

INDUSTRIAL WASTEWATER TREATMENT

ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditures (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Specialty Equipment	172	192	211	228	239	248	151	85	75	63	8.6	-23.4
Instrumentation ^b	26	31	35	38	42	44	28	17	14	13	12.7	-21.0
Subtotal	198	223	246	266	281	292	179	102	89	76	9.1	-23.0
Associated Construction	978	1077	1164	1229	1274	1293	771	448	361	324	6.8	-24.0
TOTAL	1176	1300	1410	1495	1555	1585	950	550	450	400	7.2	-23.2

^aReflects construction put-in-place.^bIncludes flow rate control, water quality monitoring, meters, remote and automatic control.

SOURCE: Arthur D. Little, Inc. estimates.

TABLE II-18

CASE III: EXPECTED COMPLIANCE SCHEDULE

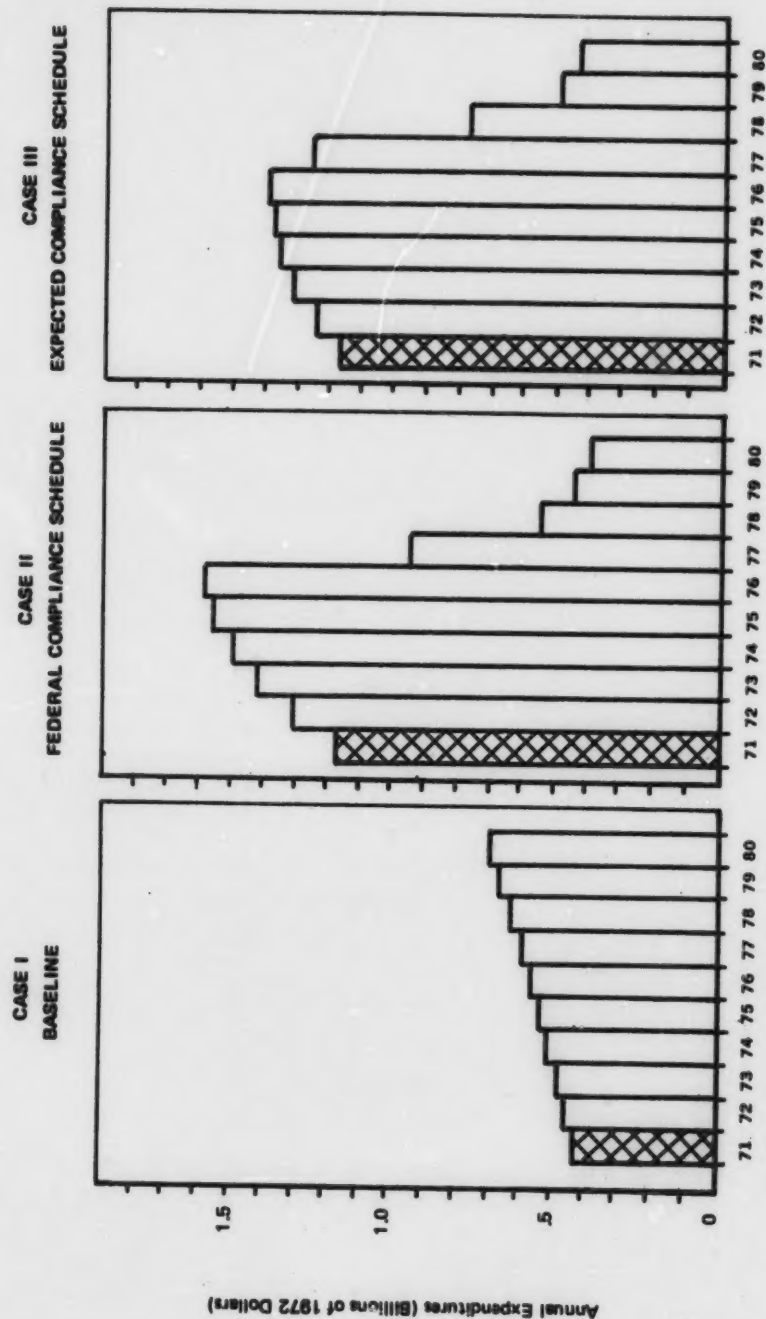
INDUSTRIAL WASTEWATER TREATMENT

ESTIMATED ANNUAL EXPENDITURES, 1972-80^a

	Annual Expenditures (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Specialty Equipment	172	184	197	207	213	217	198	124	80	73	5.5	-19.3
Instrumentation ^b	26	30	32	34	36	38	36	23	16	15	8.5	-16.1
Subtotal	198	214	229	241	249	255	234	147	96	88	5.9	-18.8
Associated Construction	978	1036	1086	1119	1136	1140	1026	633	404	362	3.8	-20.5
TOTAL	1176	1250	1315	1360	1385	1395	1260	780	500	450	4.2	-20.1

^aReflects construction put-in-place.^bIncludes flow rate control, water quality monitoring, meters, remote and automatic control.

SOURCE: Arthur D. Little, Inc. estimates.



Sources: Arthur D. Little, Inc. estimates.

FIGURE II-4 INDUSTRIAL WASTEWATER TREATMENT
COMPARATIVE EXPENDITURES, 1972-80

winding down of the surprisingly high growth rates experienced since 1968, in addition to an expiration of the retrofit market.

An enforced federal compliance schedule would perpetrate a demand on specialty equipment manufacturers which would increase at a rate (9.1%) which is greater than that of total expenditures (7.2%). Also the cumulative demand for specialty equipment and instrumentation (\$1753 million) over the decade (Table B-19) is over 100% greater than the cumulative equipment demand (\$819 million) for the baseline case.

The major variation of Case III from Case II comes from a smoothing effect that an expected slackening of enforcement would have on demand. Moreover, Figure II-4 shows an expected compliance schedule which is similar to Case II in its reduction of annual expenditures after 1976. This similarity is unlike the situations in APC and municipal sewage treatment. It suggests either that there is not all that much to be accomplished in industrial water pollution control or, possibly, that the needs have been underestimated.

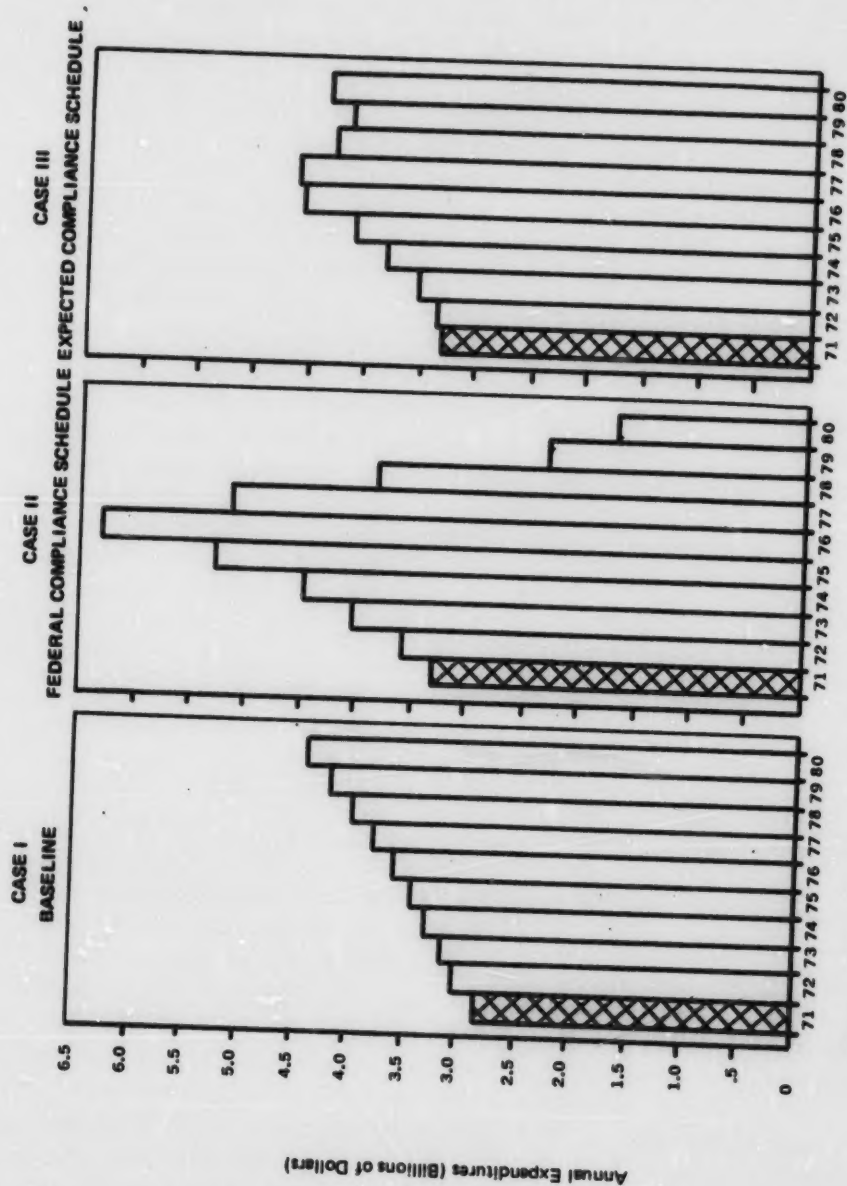
The most important disparity seen in Figure II-4 is the inordinately high level of industrial investment in 1971 in relation to the relatively low (less than \$10 billion) cumulative investment requirements. The comparative growth rates of Cases II and III pale in comparison to the annual growth which has apparently already taken place within this sector since 1969. Such a high level of initial investment and relatively low backlog, creates only minor differences between a rigidly enforced compliance policy and a more reasonable pace.

Figure II-5 summarizes the combined trends in annual expenditures for both municipal and industrial wastewater facilities. The baseline is below both the Federal and Expected Compliance Schedules because of accelerated industrial activity and in contrast to lagging municipal construction. The Federal Schedule reflects the shape of both its municipal and industrial components. The Expected Schedule, on the other hand, shows a continued increase in activity through 1976, but then levels off through 1980. This leveling of activity is the result of a projected decrease in industrial activity and a continued increase in municipal activity.

7. Critical Product Lines

In our demand analysis for both the municipal sewage and industrial wastewater treatment sectors, we have indicated that the demand for specialty equipment and instrumentation will experience a growth rate greater than the growth in annual expenditures as a whole in both Cases II and III. Likewise, Tables B-12 and B-19 summarized our estimates of cumulative demand for this equipment from 1972-80. The next step, that of identifying critical product lines, was necessarily approached more subjectively.

First, the relative usage of individual product types was determined for municipal sewage and industrial wastewater treatment. Next, those predominant types were compared with (1) our estimates of required cumulative shipments (1972-80) of each product and (2) our estimates of construction backlog by either level of treatment or type of process. This information is summarized in Tables B-20 and B-21 of Appendix B.



Source: Arthur D. Little, Inc. estimates.

**FIGURE II-5 WATER POLLUTION CONTROL
COMPARATIVE EXPENDITURES, 1972-80**

Finally, by comparing product types, we *subjectively* assessed the degree of importance of each product type from the experience of both in-house staff and industrial contacts. With reference to Table B-22, those product lines of comparatively high importance are as follows:

Municipal Sewage	Industrial Wastewater
Aerators	Chemical Feeders
Digestion	Dewatering
Dewatering	Meters and Controls
Meters and Controls	Mixers
Mixers	Pumps
Pumps	Sedimentation
Sedimentation	Water Quality Monitoring
Sludge Incineration	
Water Quality Monitoring	

This list should not infer that the absence of certain product types makes that hardware any less of a supply concern for individual projects or specific geographical regions. A more concentrated effort would be needed to properly evaluate the supply capacity for each of the 18 products types referred to in this study.

E. WASTEWATER TREATMENT CHEMICALS

Previous sections of this chapter have been concerned with the annual capital investment in pollution abatement facilities. Until this time, we have omitted discussion of the costs related to operation and maintenance of these facilities.

Although difficult to estimate accurately, we believe these O&M costs are substantial – possibly approaching the annual expenditures for specialty equipment and associated services in both air and water pollution control. Typically, these costs include expenditures for power, fuel, water, replacement parts, maintenance labor, collected waste disposal, and supplies.

While the lack of available demand data prohibited us from examining the spectrum of these annual operating costs in detail, a few specific products and services can be identified as critical. Therefore, we have limited our analysis to those chemicals supplied for sewage and wastewater treatment. This does not infer that the costs of other supplies and services will not be affected by environmental legislation – rather that the importance of the wastewater treatment chemical market warrants special attention.

Demand for wastewater treatment chemicals has been subdivided into either bulk or specialty chemicals. Bulk chemicals are considered commodities and are sold at commodity margins to a wide range of customers, and wastewater treatment demand is but a small part of their total market. As in bulk chemicals, many of the specialty chemicals have long had established markets in wastewater treatment, and have grown at somewhat higher rates in recent years. The best examples of the newer specialty chemicals used for treatment application are activated carbon and the polyelectrolytes.

1. Demand Estimates

Reliable estimates on the market for waste treatment chemicals are scarce. Also, many estimates encompass both water and wastewater treatment. Our own estimates of these markets are based on in-house resources and feedback from our industrial contacts. Table II-19 shows our general estimates for the years 1965 and 1970, for both water and wastewater applications.

Demand estimates for water and wastewater treatment (W/WT) chemicals are tied to aggregate capital investment in treatment facilities — both water and wastewater. Therefore, our demand forecasts are based upon the annual growth of *cumulative* investment in these facilities.

Table II-20 gives cumulative investment by years for both water and wastewater facilities. Investment in facilities prior to 1970 were estimated by using past publications of the Department of Commerce and EPA. Subsequent investment in municipal sewage and industrial wastewater facilities incorporates our estimates of the annual expenditures developed in Sections C and D of this chapter.

Investment in water treatment facilities were assumed to remain constant for all three cases. This infers that water plant investment is not affected by federal environmental legislation. Furthermore, we assumed annual expenditures in water supply facilities will increase at a constant rate of 3%/year (constant dollars) through 1980. This decision was made following an investigation of past investment which indicated sporadic annual growth rates. The 3%/year rate represents a combined index encompassing: (1) growth in U.S. domestic population; (2) growth in per-capita municipal (water) withdrawal; and (3) growth in percent of population served by municipal water supply systems (i.e., similar to the analysis in Table B-7).

Finally, we must relate the growth of individual W/WT chemical markets with the growth in cumulative investment. First, we have assumed that the total market for bulk chemicals will grow at a rate equal to the growth in cumulative construction investment, as will both the municipal and industrial water treatment markets for specialty chemicals. The only exception to this general assumption is that specialty chemicals will continue to make inroads in sewage and wastewater treatment, and will grow at a rate of 25% greater than cumulative construction investment. Annual demand estimates for each sector in all three cases are based upon these assumptions.

2. Case I: Baseline

Our initial expenditures for W/WT chemicals in the absence of environmental legislation are based upon cumulative baseline investment and cumulative actual investment in 1971. Estimated W/WT chemical expenditures for the baseline case are shown in Table II-21.

3. Case II: Federal Compliance Schedule

Table II-22 shows the schedule of expenditures required to support the investment made in water and wastewater treatment facilities in order to meet federal deadlines. Unlike the

TABLE II-19
WATER AND WASTEWATER TREATMENT CHEMICALS
ESTIMATED ANNUAL EXPENDITURES, 1965 AND 1971
(Millions of Current Dollars)

	<u>1965</u>	<u>1971</u>
Bulk Chemicals^a		
Municipal Water Treatment	40	55
Industrial Water Treatment	<u>25</u>	<u>35</u>
Subtotal ^b	65	90
Municipal Sewage Treatment	15	20
Industrial Wastewater Treatment	<u>10</u>	<u>15</u>
Subtotal	<u>25</u>	<u>35</u>
TOTAL	90	125
Specialty Chemicals^c		
Municipal Water Treatment	20	30
Industrial Water Treatment	<u>140</u>	<u>205</u>
Subtotal	160	235
Municipal Sewage Treatment	15	20
Industrial Wastewater Treatment	<u>15</u>	<u>20</u>
Subtotal ^d	30	40
TOTAL	190	275
GRAND TOTAL	280	400

^aIncludes chlorine, alum, lime, soda ash, ferric chlorine, ferrous sulfate, clays, and salts among others.

^bWater treatment defined to include both influent and in-process treatment.

^cIncludes coagulant aids, ion-exchange resins, slimicides, bactericides, activated carbon, and corrosion inhibitors among others.

^dIncludes technical services from suppliers, we estimated to be 10-20% of this subtotal.

SOURCE: Arthur D. Little, Inc. estimates.

TABLE II-20

WATER AND WASTEWATER TREATMENT FACILITIES
CUMULATIVE EXPENDITURES, THRU 1980

	Cumulative Expenditures (Billions of 1972 Dollars)											
	Pre 1970	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Water Treatment Facilities	64.0	66.3	68.7	71.2	73.7	76.4	79.1	81.8	84.7	87.7	90.7	93.8
Wastewater Treatment Facilities												
Case I: Municipal	54.2	56.5	59.0	61.5	64.2	67.0	69.9	72.9	76.1	79.5	83.0	86.7
Industrial	3.7	4.1	4.5	5.0	5.5	6.0	6.5	7.1	7.7	8.3	9.0	9.7
TOTAL	47.9	60.6	63.4	66.5	69.7	73.0	76.4	80.0	83.8	87.8	92.0	96.4
Case II: Municipal	53.5	55.4	57.5	59.8	62.4	65.4	69.2	73.9	78.1	81.4	83.3	84.5
Industrial	4.2	5.1	6.3	7.6	9.0	10.5	12.0	13.6	14.6	15.1	15.6	16.0
TOTAL	57.7	60.5	63.8	67.4	71.4	75.9	81.2	87.5	92.7	96.5	98.9	100.5
Case III: Municipal	53.5	55.4	57.5	59.6	61.9	64.3	67.1	70.2	73.5	77.0	80.7	84.5
Industrial	4.2	5.1	6.3	7.6	8.9	10.2	11.6	13.0	14.3	15.0	15.5	16.0
TOTAL	57.7	60.5	63.8	67.2	70.8	74.5	78.7	83.2	87.8	92.0	96.2	100.5

SOURCE: Department of Commerce; Arthur D. Little, Inc.

TABLE II-21

CASE I: BASELINE

WATER AND WASTEWATER TREATMENT CHEMICALS
ESTIMATED ANNUAL EXPENDITURES, 1972-80

	Annual Expenditures (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Bulk Chemicals^a												
Municipal Water Treatment ^b	55	57	59	61	63	65	67	70	73	76		
Industrial Water Treatment	35	36	37	38	39	40	42	44	46	48		
Subtotal	90	93	96	99	102	105	109	114	119	124	3.6	3.6
Municipal Sewage Treatment	21	22	23	24	25	26	27	28	29	31	4.3	4.4
Industrial Wastewater Treatment	11	12	13	15	16	17	19	20	22	24	9.6	8.3
Subtotal	32	34	36	39	41	43	46	43	51	55	6.4	6.1
TOTAL	122	127	132	138	143	148	155	162	170	179	4.0	4.6
Specialty Chemicals^c												
Municipal Water Treatment	30	31	32	33	34	35	36	38	40	42		
Industrial Water Treatment	205	212	220	228	236	245	254	263	272	282		
Subtotal ^d	235	243	252	261	270	280	290	301	312	324	3.6	3.6
Municipal Sewage Treatment	25	26	28	29	31	33	34	36	38	40	5.4	5.5
Industrial Wastewater Treatment	11	13	14	16	17	19	21	23	26	28	12.0	10.4
Subtotal	36	39	42	45	48	52	55	59	64	68	7.5	7.2
TOTAL	271	282	294	306	318	332	345	360	376	392	4.1	5.5
GRAND TOTAL	393	409	426	444	461	480	500	522	546	571	4.1	5.4

^aIncludes chlorine, alum, lime, soda ash, ferric chloride, ferrous sulfate, clays, and salts among others.^bWater treatment defined to include both influent and in-process treatment.^cIncludes coagulant aids, ion-exchange resins, silicicides, bactericides, activated carbon, and corrosion inhibitors among others.^dIncludes technical services from suppliers, we estimate 10-20% of this subtotal.

SOURCE: Arthur D. Little, Inc. estimates.

TABLE II-22

CASE II: FEDERAL COMPLIANCE SCHEDULE

WATER AND WASTEWATER TREATMENT CHEMICALS
ESTIMATED ANNUAL EXPENDITURES, 1972-80

	Annual Expenditures (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Bulk Chemicals												
Municipal Water Treatment	55	57	59	61	63	65	67	70	73	76		
Industrial Water Treatment	35	36	37	38	39	40	42	44	46	48		
Subtotal	90	93	96	99	102	105	109	114	119	124	3.6	3.6
Municipal Sewage Treatment	20	21	22	23	24	26	27	28	29	29	4.7	3.8
Industrial Wastewater Treatment	15	18	21	25	29	32	35	36	37	38	17.9	5.6
Subtotal	35	39	43	48	53	58	62	64	66	67	10.9	4.8
TOTAL	125	132	139	147	155	163	171	178	185	191	5.5	4.3
Specialty Chemicals												
Municipal Water Treatment	30	31	32	33	34	35	36	38	40	42		
Industrial Water Treatment	205	212	220	228	236	245	254	263	272	282		
Subtotal	235	243	252	261	270	280	290	301	312	324	3.6	3.6
Municipal Sewage Treatment	20	21	22	23	25	27	29	31	32	32	5.7	5.1
Industrial Wastewater Treatment	20	25	31	37	44	51	56	59	61	63	21.8	7.4
Subtotal	40	46	53	60	69	78	85	90	93	95	14.6	6.6
TOTAL	275	289	305	321	339	358	375	391	405	419	5.4	4.3
GRAND TOTAL	400	421	444	468	494	521	546	569	590	610	5.4	4.3

^aIncludes chlorine, alum, lime, soda ash, ferric chlorine, ferrous sulfate, clays, and salts among others.
^bWater treatment defined to include both influent and in-process treatment.

^cIncludes coagulant aids, ion-exchange resins, slimicides, bactericides, activated carbon, and corrosion inhibitors among others.

^dIncludes technical services from suppliers, we estimate 10-20% of this subtotal.

SOURCE: Arthur D. Little, Inc. estimates.

specialty equipment and instrumentation markets, the W/WT chemical estimates were not adjusted to allow for our perception of the possible response from private and public sector customers. As we have defined the market, demand for W/WT treatment chemicals is only an indirect function of federally-imposed compliance schedules, and as a result, demand is only slightly affected.

4. Case III: Estimated Compliance Schedule

Our estimates of demand for W/WT chemicals under our expected enforcement schedule are shown in Table II-23. As in Case II, annual demand is only indirectly responsive to the imposed compliance schedule.

5. Comparative Expenditures

Referring to Figure II-6, there appears to be only minor variations in W/WT chemical expenditures between the baseline case and either Case II or Case III. The 1971 estimated demand in the baseline case (\$393 million) is but 2% below our estimates of actual demand in that year (\$400 million), an amount easily negated by the probable magnitude of error in the estimates. The major difference appears in the industrial wastewater sector where demand was \$22 million in the baseline versus our estimate of \$35 million. This is somewhat offset by a baseline demand for municipal sewage treatment chemicals of \$46 million versus our estimate of \$40 million in Cases II and III. There appear to be no major variations between Cases II and III. However, a small differential market was created by variations in the growth rates between the baseline case and Cases II and III. The 1980 estimate of approximately \$610 million in the latter two cases is approximately 7% greater than the baseline estimate (\$571 million), up from the 2% difference in 1971.

F. SUMMARY

Table II-24 summarizes our estimated annual equipment (and chemical) shipments for each industry sector under each of the three scenarios. It is of concern that the Federal Compliance Schedules (Case II's) threaten to create a *negative* growth market for both specialty equipment and instrumentation in each of the three durable goods investment sectors. W/WT chemicals will continue to experience a positive growth rate due to its dependence on cumulative investment.

In comparing the Expected Compliance Schedules (Case III's), the industrial wastewater treatment field is the only sector in which estimated potential backlog will be taken care of by the middle of the decade. This was caused by the combination of extending the rapid growth in estimated industrial wastewater abatement construction over the period 1968 to 1971 with the relatively small demand potential still remaining.

Again, comparing the Case III's, the gaseous control equipment market is the only sector in which the growth over the latter half of the decade approaches or exceeds the growth over the period 1971 to 1975. This is largely explained by the proven enormous retrofit market presented by coal-fired stream-electric power plants.

TABLE II-23

CASE III: EXPECTED COMPLIANCE SCHEDULE

WATER AND WASTEWATER TREATMENT CHEMICALS

ESTIMATED ANNUAL EXPENDITURES, 1972-80

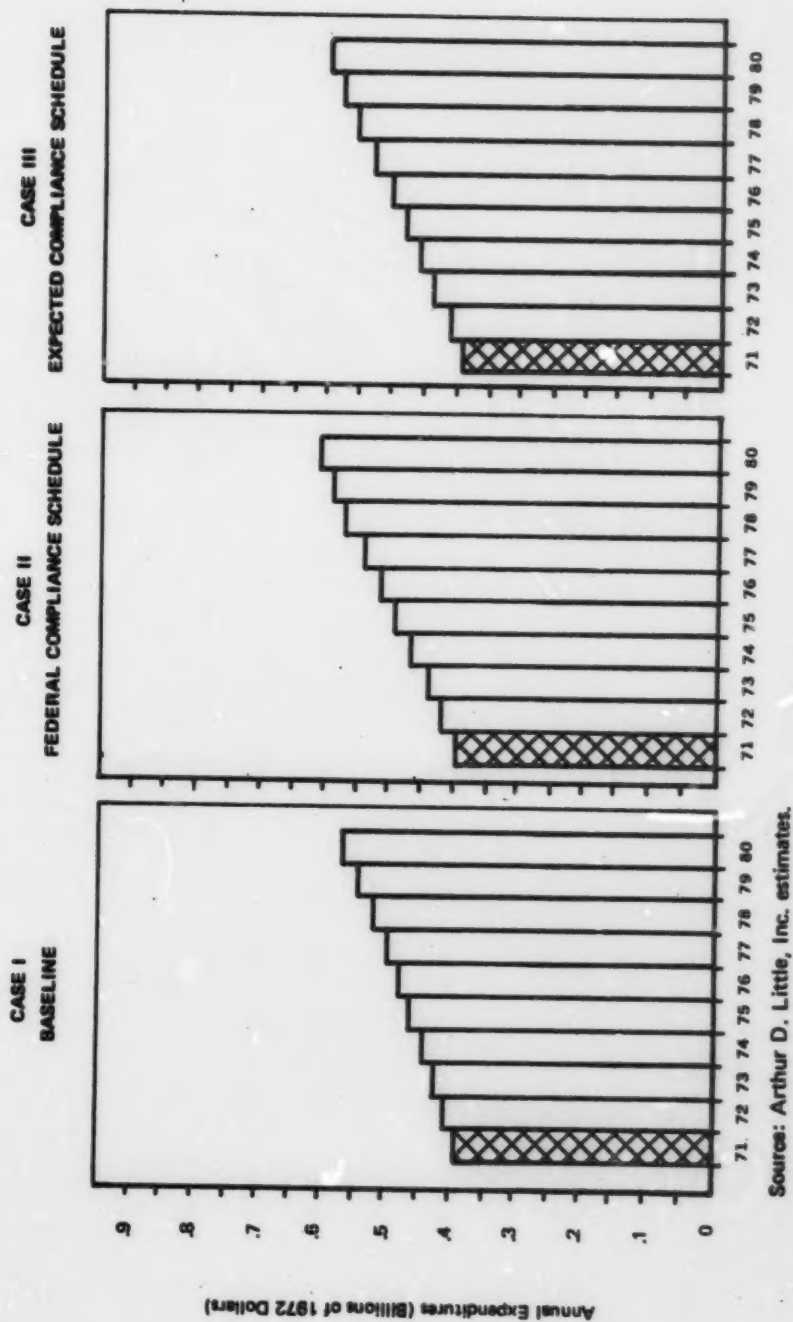
	Annual Expenditures (Millions of 1972 Dollars)											Growth (Z/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980		1971-75	1975-80
Bulk Chemicals													
Municipal Water Treatment	55	57	59	61	63	65	67	70	73	76			
Industrial Water Treatment	35	36	37	38	39	40	42	44	46	48			
Subtotal	90	93	96	99	102	105	109	114	119	124		3.6	3.6
Municipal Sewage Treatment	20	21	22	22	23	24	26	27	28	29		3.6	4.7
Industrial Wastewater Treatment	15	18	21	24	27	31	34	35	37	38		15.8	7.1
Subtotal	35	39	43	46	50	55	60	62	65	67		9.3	6.0
TOTAL	125	132	139	145	152	160	169	176	184	191		5.5	4.7
Specialty Chemicals													
Municipal Water Treatment	30	31	32	33	34	35	36	38	40	42			
Industrial Water Treatment	205	212	220	228	236	245	254	263	272	282			
Subtotal	235	243	252	261	270	280	290	301	312	324		3.6	3.6
Municipal Sewage Treatment	20	21	22	23	24	26	27	29	31	32		4.7	5.9
Industrial Wastewater Treatment	20	25	30	36	42	48	54	58	60	62		20.4	8.1
Subtotal	40	46	52	59	66	74	81	87	91	94		13.3	7.3
TOTAL	275	289	305	320	336	354	371	388	403	418		5.1	4.5
GRAND TOTAL	400	421	444	465	488	514	540	564	587	609		5.1	4.5

^a Includes chlorine, alum, lime, soda ash, ferric chlorine, ferrous sulfate, clays, and salts among others.
^b Water treatment defined to include both influent and in-process treatment.

^c Includes coagulant aids, ion-exchange resins, slimicides, bactericides, activated carbon, and corrosion inhibitors among others.

^d Includes technical services from suppliers, we estimate 10-20% of this subtotal.

SOURCE: Arthur D. Little, Inc. estimates.



Source: Arthur D. Little, Inc. estimates.

FIGURE II-6 WASTEWATER TREATMENT CHEMICALS
COMPARATIVE EXPENDITURES, 1972-80

TABLE II-34

ESTIMATED POLLUTION ABATEMENT EQUIPMENT SHIPMENTS, 1972-80

		Annual Shipments (Millions of 1972 Dollars)										Growth (%/year)	
		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
A. AIR POLLUTION CONTROL													
Case I: Baseline													
Particulate Control		104	111	117	124	130	137	144	152	160	167	5.4	5.4
Gaseous Control		20	21	21	22	23	24	24	25	25	26	5.4	5.4
Subtotal		114	122	128	136	143	151	158	167	175	183	5.4	5.4
Instrumentation		8	8	8	9	9	10	10	11	11	12	5.4	5.4
Case IIa: Federal Compliance Schedule													
Particulate Control		201	247	361	570	935	530	269	151	97	78	46.9	-39.2
Gaseous Control		42	50	66	95	152	243	164	99	76	64	37.9	-15.9
Subtotal		243	297	427	665	1087	773	433	250	173	142	45.4	-33.5
Instrumentation		15	28	40	62	102	80	49	29	21	17	61.4	-30.2
Case IIb: Federal Compliance Schedule													
Particulate Control		201	221	251	326	496	220	158	126	99	80	25.3	-30.6
Gaseous Control		42	50	76	135	262	325	374	135	106	94	57.9	-18.5
Subtotal		243	271	327	461	758	745	532	261	205	174	32.9	-25.5
Instrumentation		15	25	31	43	71	70	50	25	19	16	47.5	-25.8
Case IIIa: Expected Compliance Schedule													
Particulate Control		201	214	234	281	310	340	357	395	441	471	11.4	8.7
Gaseous Control		42	46	53	62	70	86	108	142	171	208	13.6	24.6
Subtotal		243	260	287	343	380	426	465	537	612	679	11.8	12.3
Instrumentation		15	20	25	31	40	46	53	61	70	80	27.7	14.9
Case IIIb: Expected Compliance Schedule													
Particulate Control		201	214	234	281	310	320	285	153	104	74	11.4	-24.9
Gaseous Control		42	51	63	86	113	147	199	292	327	344	28.1	24.9
Subtotal		243	265	297	367	423	467	484	445	431	418	14.9	-0.2
Instrumentation		15	20	25	31	40	46	53	61	70	80	27.8	14.9
B. MUNICIPAL SEWAGE TREATMENT													
Case I: Baseline													
Specialty Equipment		96	100	104	109	114	119	125	132	138	145	4.3	5.0
Instrumentation		11	12	12	13	13	14	15	15	16	17	4.3	5.0
Case II: Federal Compliance Schedule													
Specialty Equipment		110	126	159	221	292	368	300	211	113	73	27.6	-24.4
Instrumentation		17	21	28	39	54	78	65	52	23	13	33.0	-23.0
Case III: Expected Compliance Schedule													
Specialty Equipment		110	114	123	152	186	222	239	255	277	293	14.1	9.5
Instrumentation		17	19	21	26	33	42	48	54	62	69	17.9	15.9
C. INDUSTRIAL WASTEWATER TREATMENT													
Case I: Baseline													
Specialty Equipment		56	59	63	66	69	73	77	81	86	91	5.4	5.4
Instrumentation		13	14	14	15	16	17	18	19	20	21	5.4	5.4
Case II: Federal Compliance Schedule													
Specialty Equipment		172	192	211	228	239	248	151	85	75	63	8.6	-23.4
Instrumentation		26	31	35	38	42	44	28	17	14	13	12.7	-21.0
Case III: Expected Compliance Schedule													
Specialty Equipment		172	184	197	207	213	217	198	124	80	73	5.5	-19.3
Instrumentation		26	30	32	34	36	38	36	23	16	15	8.5	-16.1
D. WATER AND WASTEWATER TREATMENT CHEMICALS													
Case I: Baseline													
Bulk Chemicals		122	127	132	138	143	148	155	162	170	179	4.0	4.6
Specialty Chemicals		271	282	294	306	318	332	345	360	376	392	4.1	5.5
Case II: Federal Compliance Schedule													
Bulk Chemicals		125	132	139	147	155	163	171	178	185	191	5.5	4.3
Specialty Chemicals		275	289	305	321	339	358	375	391	405	419	5.4	4.3
Case III: Expected Compliance Schedule													
Bulk Chemicals		125	132	139	145	152	160	169	176	184	191	5.5	4.7
Specialty Chemicals		275	289	305	320	336	354	371	388	403	418	5.1	4.5

SOURCE: Arthur D. Little, Inc., estimates.

As to the artificial creation of a durable goods market due to environmental legislation, there can be no doubt. Actual demand for specialty equipment and instrumentation exceeded baseline demand in all sectors, as can be seen from Table II-25. The single most affected market is gaseous pollution control equipment with a minimum increase in cumulative demand of 540%.

Finally, the growth in specialty equipment demand *exceeds* the growth in annual expenditures under either Case II or Case III in virtually all sectors. This is due to not only a general increase in abatement construction activity, but also to a gradual trend towards advanced treatment.

TABLE II-25
POLLUTION ABATEMENT EQUIPMENT^a
CUMULATIVE EQUIPMENT SHIPMENTS THROUGH 1980

Sector	Cumulative Shipments (Millions of 1972 Dollars)		Additional Shipments (Percent)
	Without Environmental Legislation	With Environmental Legislation	
AIR POLLUTION CONTROL ^c			
Specialty Equipment			
Particulate Control	1929	1977-4199 ^e	3-120%
Gaseous Control	185	1186-1757 ^e	540-850%
Instrumentation	144	506	250%
WATER POLLUTION CONTROL ^d			
Specialty Equipment			
Municipal Sewage Treatment	1610	2409	50%
Industrial Wastewater Treatment	981	2075	110%
Instrumentation	419	793	90%
WASTEWATER TREATMENT CHEMICALS			
Bulk Chemicals	1999	2116	5%
Specialty Chemicals	4415	4626	5%
TOTAL	11682	17910	50%

^a Equipment proper only; excludes associated services.

^b Incorporates New Source Performance Standards for air pollution when applicable; assumes water pollution abatement approaches equivalent secondary treatment.

^c Assumed base year - 1963.

^d Assumed base year - 1965

^e Depends upon assumptions concerning present availability of adequate gaseous control technology.

Chapter III. IMPACT ANALYSIS

A. THEORETICAL BASIS

The demand analysis of our report has focused upon the cycles of demand for pollution abatement equipment given different assumptions. The three different sets of assumptions have been formulated into three alternative futures: Case I – Baseline; Case II – Federal Compliance Schedule; and Case III – Expected Compliance Schedule.

However, these demand projections have thus far ignored the supply capabilities of the relevant pollution abatement industries. Our demand estimates are actually supply-demand intercepts, assuming either perfectly elastic supply from the pollution abatement industries or zero demand elasticity to price.

It is, of course, clear that supply will not be perfectly elastic over the 1970-1980 decade. The Federal Compliance Schedule (Case II) exerts an inelastic demand upon the pollution abatement industries. These industries in turn will require significant increases in their labor, capital, and materials needs. Under Case II as the pollution abatement industries increase production to meet the peak demands in 1975 or 1976, they will be forced to bid up the real prices of their factors of production. For example, the real price of project and design engineers, of draftsmen, and of production laborers will be bid up. Such increased factor costs will affect the real price of the pollution abatement equipment or at least exert pressures on those prices.

It is the task of this chapter to estimate the extent to which these increased factor costs will exert proportional pressures on the price of the pollution abatement equipment. The process of analysis is a non-simultaneous simulation of what is, in the marketplace, a simultaneous one. It utilizes a production function approach which is a hybrid of neoclassical and fixed-factor proportion production function theories. In particular we assume nearly fixed-factor proportions throughout the decade. The process is first discussed theoretically, followed by a discussion of some of its assumptions and limitations.

1. Desired Results

The demand data has been quantified for APC and WPC equipment separately. Expenditures for air pollution control have been further broken out for particulate control, gaseous control, and instrumentation. The data for WPC equipment demand is given for specialty equipment, specialty chemicals and instrumentation. The yearly volume of each type of demand is projected in 1972 dollars.

The three alternative demand futures, Cases I-III, posited for each of the pollution abatement industries are represented generally in Figure III-1. These projections are expressed in 1972 dollars and assume 1972 production relationships and supply availabilities. We must now adjust these curves over time by examining factor elasticities, factor supply and price, and changes in productivity. For example, in Figure III-1, b, if operating rates were already high, the bottlenecks in factor supply would cause the actual expenditure schedule in real dollars to look like AA. In other words, the real price would be adjusted above the 1972 dollar scenario as a result of real factor cost increases.

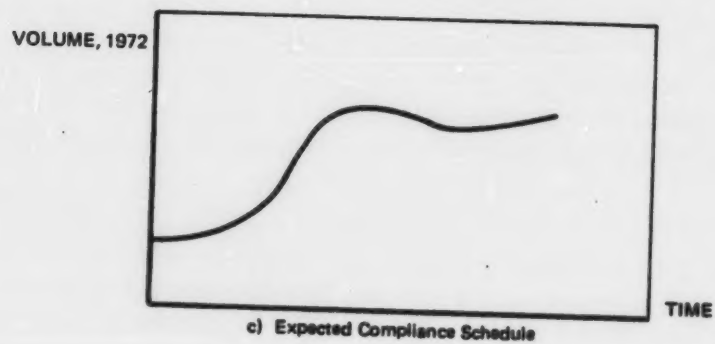
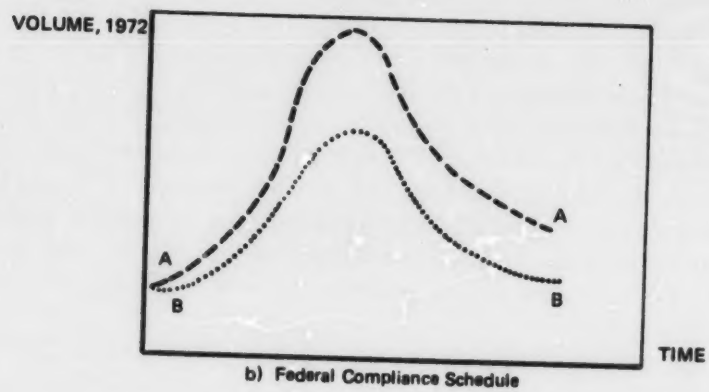
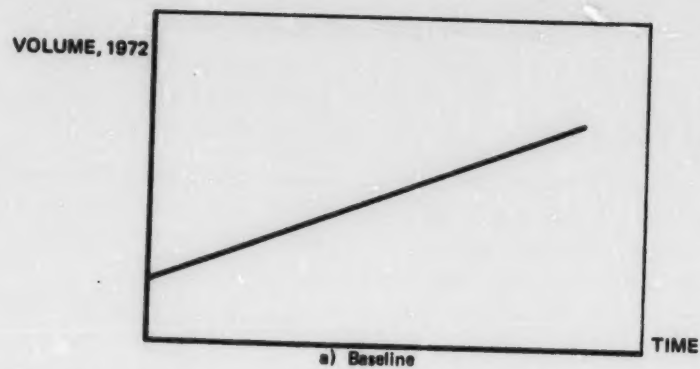


**FIGURE III-1 GENERAL SCHEMATIC DIFFERENCES
BETWEEN COMPLIANCE SCHEDULES**

On the other hand, if excess capacity were initially available, factor inputs were in relatively elastic supply, and new technology were to be introduced, the real price of the pollution equipment could actually be lower (to BB in Figure III-1,b).

In any case, our "cost-of-supply" analysis indicates how much the actual dollar volume will differ in each year from our first estimates, given changes in relative factor prices.

2. The Process

This process, or analytic model, focuses primarily upon the supply-side characteristics of the pollution abatement industries. The approach assumes demand is inelastic with compliance schedules (both legislated and expected versions) and is concerned with those changes in the final product price that could result from changes in factor costs, only.

The model utilizes traditional production function theory. For expositional purposes we assume that there are three generic factor inputs: labor (L), capital (K), and fabricated materials (M). Total output (Q) is a function of the three inputs.

$$(1) \quad Q = f(L, K, M)$$

For our specific analyses, we disaggregated L into several types of skilled and unskilled labor, K into several types of capital inputs and M into several types of processed or fabricated materials. Our generic labor factor was disaggregated as follows:

- administration and management
- sales and technical service staff
- project and design engineering
- R&D and laboratory staff
- draftsmen
- production, maintenance, and operation manpower

Materials were broken out into:

- manufactured or fabricated inputs
- raw material resources

The capital analysis focused upon:

- interest
- depreciation
- net income

These three factors and their "factors markets" are discussed in detail following this theoretical discussion.

If we assume that f is homogeneous of degree one, that perfect competition exists in factor and product markets, and that firms are profit-maximizers we can write:

$$(2) \quad Q = f_L L + f_K K + f_M M$$

$$\text{or } (2a) \quad Q = \frac{\partial Q}{\partial L} L + \frac{\partial Q}{\partial K} K + \frac{\partial Q}{\partial M} M$$

$$\text{or } (2b) \quad Q = P_L L + P_K K + P_M M$$

where:

the price of the final product Q is unity (if it were not we could normalize on it), and

P_L , P_K , and P_M are the prices per units of labor, capital, and materials, respectively.

Equations (2)-(2b) merely state that a producing firm distributes total revenues to profits and different factors of production. By manipulating (2a) we can obtain (2c):

$$(2c) \quad 1 = \frac{\frac{\partial Q}{\partial L}}{\frac{Q}{L}} + \frac{\frac{\partial Q}{\partial K}}{\frac{Q}{K}} + \frac{\frac{\partial Q}{\partial M}}{\frac{Q}{M}}$$

where $\frac{\partial Q}{\partial L} / \frac{Q}{L}$ is the output elasticity of labor

$\frac{\partial Q}{\partial K} / \frac{Q}{K}$ is the output elasticity of capital

$\frac{\partial Q}{\partial M} / \frac{Q}{M}$ is the output elasticity of materials.

The output elasticities of each input indicate the proportional increase in output generated by a proportional increase in that input. These elasticities add to 1 because we have assumed a production function of constant returns to scale.

This analysis must be altered slightly to fit our supply analysis. The demand data we have estimated is not in physical quantity units, but rather 1972 dollar volume. However, we can let 1972 dollar volumes act as proxies of Q , the quantity supplied by one of our pollution abatement industries. As such, Q is the constant dollar volume of particulate equipment in year 1977.

We are interested in volumes produced over time, and have therefore geared our analysis to be sequential. Therefore we express production in a given year as Q_t . Therefore, we have for one of our pollution abatement industries (let us say industry 1):

$$(3) \quad Q_t = f^1(L_t, K_t, M_t)$$

Q_t , L_t , K_t and M_t in Equation (3) in theory are stated in physical units. However, in order to estimate Equation (3) in pollution abatement industries we must utilize the income accounts data which is available to us. Therefore, as in our demand estimates, our quantity estimates of factor inputs have been expressed in 1972 dollar volume. In that case Equation (3) becomes:

$$(3a) \quad \hat{Q}_t = f^1(\hat{L}_t, \hat{K}_t, \hat{M}_t) \quad , t = 1972$$

where:

$\hat{Q}_t$ is the volume of pollution abatement equipment measured in 1972 dollars.

$\hat{L}_t$ is the total wage and salary bill paid by industry 1.

$\hat{K}_t$ is the dollar volume capital return in industry 1.

$\hat{M}_t$ is the dollar volume of fabricated materials used by industry 1.

Note that in 1972 the basic accounting identity must hold:

$$(3b) \quad \hat{Q}_{1972} = \hat{L}_{1972} + \hat{K}_{1972} + \hat{M}_{1972}$$

In other words, total net receipts must equal total payments to labor, capital, and materials. Equation (3a) is the basic form of the production function to be used. $\hat{Q}_t$ is produced each year by the necessary inputs $\hat{L}_t$, $\hat{K}_t$, $\hat{M}_t$, all in 1972 dollars. We shall utilize (3a) for $t = 1971$ through 1980. In 1972, equation (3a) is a statement of what actually holds. As $t = 1973-1980$, however, $\hat{L}_t$, $\hat{K}_t$, and $\hat{M}_t$ will change because as more or less $\hat{K}_t$, $\hat{M}_t$, and $\hat{L}_t$ are required their relative prices will change. Our analysis must take into account the effects of such relative price changes upon the factor cost mix.

To quantify such changes we need to rewrite equation (3a) as follows:

$$(4) \quad P_t \hat{Q}_t = \hat{P}_t^L \hat{L}_t + \hat{P}_t^K \hat{K}_t + \hat{P}_t^M \hat{M}_t$$

or

$$(4a) \quad P_t \hat{Q}_t = \frac{\partial(P_t \hat{Q}_t)}{\partial \hat{L}_t} \hat{L}_t + \frac{\partial(P_t \hat{Q}_t)}{\partial \hat{K}_t} \hat{K}_t + \frac{\partial(P_t \hat{Q}_t)}{\partial \hat{M}_t} \hat{M}_t$$

where:

P_t is the "price" of the pollution abatement equipment in year t . It is, in essence, the scaling factor to be quantified. For example, if we calculate P_t to be 1.3, it will tell us that the real dollar volume of output in year t would be 1.3 times as great as our original estimate, Q_t , as a result of supply considerations.

$\hat{Q}_t$ is the constant dollar (1972) volume of pollution abatement equipment produced in year t, as estimated earlier in Chapter II.

$\hat{P}_t^L$ is the "price" of labor in year t. It is likewise a scaling factor — to be applied to the 1972 dollar volume of labor necessary in year t, in order to reflect relative labor scarcity in that year.

$\hat{L}_t$ is the constant dollar (1972) volume of labor in pollution abatement industry 1 necessary to produce $\hat{Q}_t$.

$\hat{P}_t^K$ is the "price" of capital in year t. It is a scaling factor used to indicate the relative scarcity of capital in year t.

$\hat{K}_t$ is the 1972 dollar volume of capital needed by pollution abatement industry 1 to produce $\hat{Q}_t$.

$\hat{P}_t^M$ is the "price" of materials in year t. Again, $\hat{P}_t^M$ is a scaling factor indicating the relative scarcity of materials in year t.

$\hat{M}_t$ is the 1972 dollar volume of materials and fabricated inputs required to produce $\hat{Q}_t$ in year t.

Given equations (4) and (4a), our main interest is to estimate P_t . If we calculate P_t for each year t, we shall have the scaling factor over time necessary to adjust our constant dollar scenarios in Figure I-1 to real dollar scenarios (still in 1972 dollars relative to the general economy) reflecting factor supply scarcities over time.

In order to quantify P_t we need to quantify the scaling factors $\hat{P}_t^K$, $\hat{P}_t^M$, and $\hat{P}_t^L$. In order to better utilize quantified estimates of those scaling factors we rewrite equation (4) to obtain as a basic working equation:

$$(5) \quad P_t = \hat{P}_t^L \frac{\hat{L}_t}{\hat{Q}_t} + \hat{P}_t^K \frac{\hat{K}_t}{\hat{Q}_t} + \hat{P}_t^M \frac{\hat{M}_t}{\hat{Q}_t}$$

Equation (5) permits a certain amount of flexibility in assessing the factors determining $\hat{P}_t$. $\hat{L}_t/\hat{Q}_t$, $\hat{K}_t/\hat{Q}_t$, and $\hat{M}_t/\hat{Q}_t$ may be viewed as input-output coefficients in constant 1972 value terms. They are, in that sense, coefficients of average labor, capital, and materials productivity. These ratios or coefficients can be calculated from corporate profit-and-loss sheet data, i.e., data we have obtained from pollution abatement companies.

Assuming constant technology over the decade, these three ratios will remain constant. In that case, we shall be able to project the capital, labor, and material requirements over the decade from the estimated $\hat{Q}_t$. For example, if $\hat{L}_{1972}/\hat{Q}_{1972} = .50$ and $\hat{Q}_{1977} = \$40$ million then $\hat{L}_{1977} = \$20$ million.

If we had sufficient data, we could reflect changing productivity by changing these ratios over time. For example, if we expect labor productivity to rise by $X\%$ each year, $\hat{L}_t/\hat{Q}_t$ will decrease by $X\%$ each year. In that case, for each year less labor in constant 1972 dollars ($\hat{L}_t$) will be necessary to produce $\hat{Q}_t$.

By forecasting productivity changes over the 1972-1980 period, we could quantify $\hat{L}_t/\hat{Q}_t$, $\hat{K}_t/\hat{Q}_t$, and $\hat{M}_t/\hat{Q}_t$. Our actual analysis assumes however that $\hat{L}_t/\hat{Q}_t$, $\hat{K}_t/\hat{Q}_t$, and $\hat{M}_t/\hat{Q}_t$ remain constant (on a unit, not dollar, basis) throughout the decade. Thus we have assumed no changing productivities.

Finally, in order to calculate P_t for 1972-1980, we need to calculate the changes in the scaling factors $\hat{P}_t^L$, $\hat{P}_t^K$, and $\hat{P}_t^M$ for each t as $\hat{L}_t$, $\hat{K}_t$, and $\hat{M}_t$ vary for non-productivity reasons, i.e., changes in relative factor costs. These scaling factors are determined by supply elasticities and production relationships in each year.

In 1972, $\hat{P}_{1972}^L$, $\hat{P}_{1972}^K$, and $\hat{P}_{1972}^M$ are, of course, equal to 1. If factor supplies prove to be perfectly elastic for $t = 1973-80$, the scaling factors will be equal to 1 for all t 's and all factors. In other words, when labor, capital, and materials are easily available, then equation 5 tells us that the scaling factor P_t could only vary with productivity or technology changes. If productivity remains constant, as we have assumed, then P_t shall be 1 over the decade and our demand estimates in 1972 dollars will be exact estimates of demand/supply intersections in 1972 dollars.

However, we are assuming constant technology and productivity. Furthermore, it is clear that some factors will not be in perfectly elastic supply. If labor is in inelastic supply, as $\hat{L}_t$ rises, $\hat{P}_t^L$ shall rise, thereby raising P_t . Thus, we must look to each factor market and assess the elasticity of supply. For that, supply curves of capital, labor and materials are required.

The above process provides the basis for assessing the effects upon product price of changing factor demands over the decade. The basic building blocks of the process in practice will be short-run elasticity analyses of each factor market for each year of analysis.

3. Review of Assumptions

Before discussing individual factor supply curves, several of the underlying assumptions of our model deserve review. The first assumption is the apparent fixity of $\hat{K}_t/\hat{Q}_t$, $\hat{L}_t/\hat{Q}_t$ and $\hat{M}_t/\hat{Q}_t$ over time, particularly when these ratios are measured in 1972 at a time of severe over-capacity. Fixed factor ratios over a nine-year period is not an extreme assumption. At the level of aggregation considered, such ratios would change only very slowly. As a matter of history, individual input/output coefficients as estimated by BLS for very particular types of labor and intermediate inputs change very slowly over five- to ten-year periods. Only if sweeping technological change were introduced would input/output coefficients (i.e., our factor ratios) change substantially. Such sweeping technological change is not foreseen in the pollution abatement industries before 1980.

The estimation of the fixed factor proportions using 1972 data however does present a problem, given the excess capacity extent in the pollution abatement industries. We have incorporated the presence of the excess capacity by permitting the fixed-cost-type factor coefficients to decline until full capacity is reached. At full capacity the factor ratios then become constant with increasing volume. Such excess capacity is particularly prevalent in

skilled and salaried labor and in plant and equipment. Production labor and materials inputs are considered as variable costs and assumed to be used as needed.

The second major assumption of this analytic model is that demand is completely inelastic. Given an inelastic demand, the model then assesses the effects of rising factor costs upon product price. The assumption of totally inelastic demand was necessitated by the sheer absence of the requisite data upon which to estimate the real slope of a demand curve. Of course, the only case in which an elastic demand curve would be important would be in Case III, the Expected Compliance Schedule. Baseline (Case I) projections, as extensions of the recent past, are not sufficiently dramatic to cause any supply constraints and/or subsequent demand readjustments for price increases.

If data were available for precise estimation, we feel that the demand curve for Case III would be quite inelastic. In Case II, the Federal Compliance Schedule, where industries and municipalities are required by law to comply, demand is exactly what we have assumed - inelastic. In Case II final price will be determined by supply considerations entirely, i.e., by vertical demand curves intersecting supply curves. In Case III, our projections of demand have already incorporated some of the effects of a sloping demand curve - we just don't know how much. In Case III, demand is certainly somewhat elastic. However, it should still remain highly inelastic because the legal framework is still in the background enforcing ultimate compliance.

B. SUPPLY CURVES

Our simulation of true supply curves calls for supply/price elasticities of the three major factors of production: labor, capital, and materials. To blend reality into the difficult quantification of these supply elasticities, we relied on the cooperation and inputs of selected pollution abatement companies.¹ We interviewed individual firms in each of the APC and WPC equipment, instrumentation, and specialty chemicals industries. We also supplemented our data base by interviews with employment agencies which supply the skilled labor (the sales, engineering, laboratory and management personnel) to the pollution abatement industries. Similarly, we supplemented our knowledge on the availability of capital to these industries from conversations with leading banks in the field. In this manner, our factor supply elasticities are grounded in reality.

1. Elasticity of Labor Supply

The labor elasticities of supply were surveyed for:

- administration and management personnel
- sales and technical service staff
- project and design engineers
- draftsmen
- production, maintenance and operation staff.

¹So as to better protect the confidential nature of this information, we are unfortunately unable to acknowledge the help of these companies by listing them here. Nonetheless, we are grateful for their assistance.

Such information was gathered on pages 2-4 of the questionnaire presented in Appendix C, Exhibit C-1. Estimates of unit salary or wage increases were requested for increasing levels of labor demand, i.e., at 150%, 200%, 300%, and 400% of current levels. The increased wage costs reflect the scarcity or bidding cost to the firm of hiring additional staff. It is assumed that the firms would also pay their existing staff this increased premium – else they would be bid away by other pollution firms.

It was found, in general, that project and design engineers could be recruited nationally but that such recruiting increased the cost to the hiring firm in the form of moving costs. Draftsmen, on the other hand, are usually recruited regionally. Hence, some regions of the country will find draftsmen to be less of a bottleneck than others.

The analysis was conducted for the following industry groups:

- the particulate and gaseous control equipment industry
- the combined APC and WPC instrumentation industry
- the WPC specialty equipment industry
- the specialty chemicals industry.

The supply curves resulting from this survey are presented in Appendix C, Figures C-1 to C-4.

The particulate and gaseous equipment industries have been grouped together since they represent largely similar company groupings and draw upon the same types of labor and materials. Their labor supply curves are estimated in Appendix C, Figures C-1a, b. The two most important labor constraints to this industry are project and design engineers and draftsmen. Firms can recruit nationally for project and design engineers but do have to pay an added premium for relocation costs. Draftsmen are recruited locally; hence they are subject to regional supply problems. Our analysis has tapped firms and employment agencies in various regions, thereby smoothing these differences in local supply. Production labor does not appear to be a problem, although the situation does vary regionally. Figure C-1b in Appendix C subsequently exhibits a much more elastic supply for production labor than for skilled labor.

For the instrumentation industry, good design and project engineers and draftsmen are again relatively expensive to obtain. However, sales and technical service staff appears to be a more binding constraint for this industry than for particulate and gaseous equipment. Some interviews indicated that R&D staff is also spread rather thin. The supply of draftsmen again varies regionally and, for some firms, represents the most inelastic supply factor. In Appendix C, Figure C-2, the elasticity of skilled labor ranges between 3 and 8 while that of production labor ranges between 8 and 14. In general, production labor is a less elastic supply factor for the instrumentation business than for the APC equipment industry. This reflects the more specialized nature of production labor in the instrumentation industry.

The WPC equipment industry confronts some of the same factor supply inelasticities as the preceding industries. Engineers and draftsmen in general are the most inelastic in supply, while R & D staff and technical service staff are also relatively inelastic in supply. Supply elasticities are charted in Appendix C, Figures C-3a, b. Again production labor is in much

less elastic supply in this industry than in the APC equipment industry. The specialty chemicals portion of the WPC industry finds technical service staff to be its most binding labor constraint. The industry in general uses no draftsmen. The specialty chemicals industry's supply curves are found in Appendix C, Figures C-4a, b.

The questionnaire in Appendix C, Exhibit C-1 when completed provides supply curves and resultant elasticities of supply for each type of labor. Using the information in the number of employees that a firm employs, a weighted average of the individual labor supply curves can be obtained for each firm. Our analysis has grouped administration and management, sales and technical services, project and design engineering, R & D and laboratory staff, and draftsmen together as salaried labor. A weighted-average supply curve for salaried labor results for each firm. Averaging these salaried labor supply curves across all firms yields an industry supply curve.

The resulting curves are those presented in Appendix C. For expositional purposes we chart in Figure III-2 the labor supply curves for APC and WPC instrumentation industry. We have based these curves on three to five data sources for each industry. Figure III-2a reveals that in order to double the labor input to the instrumentation industry, the industry would pay on an average an 11.6% salary premium to both additional and already-employed staff. If the industry were to triple its demand for salaried labor in a given year the salary premium would be 21.8%. Between 200% ($2\hat{L}^s$) and 300% ($3\hat{L}^s$) the effective elasticity of supply is

$$5.5 \left(\frac{\Delta Q/Q}{\Delta P/P} = \frac{.5}{.0914} \right)$$

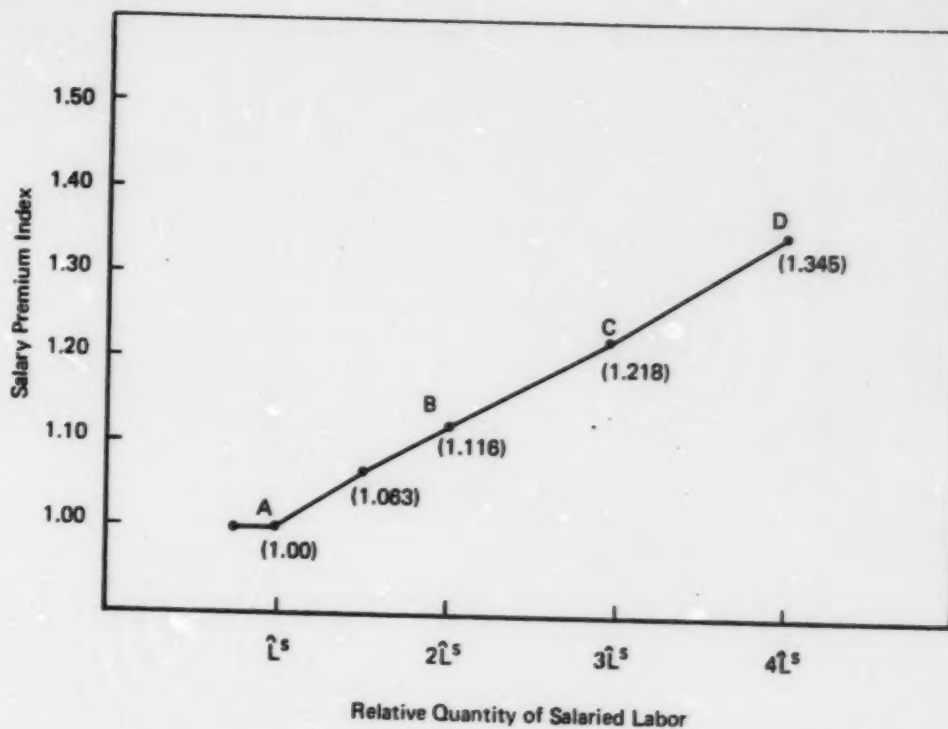
Between hiring levels of ($\hat{L}^s$) and 200% ($2\hat{L}^s$), the elasticity of supply is

$$8.6 \left(\frac{\Delta Q/Q}{\Delta P/P} = \frac{1}{.116} \right)$$

As would be expected, supply becomes less and less elastic as more and more labor is needed. Between $3\hat{L}^s$ and $4\hat{L}^s$ the elasticity of supply is

$$3.2 \left(\frac{.333}{.104} \right)$$

Likewise the production labor supply curve is an average across various firms and regions for the instrumentation industry. That supply curve is charted in Figure III-2b. As is clear from the elasticity figures, and as would be expected, the supply of production labor is more elastic than the more specialized salaried labor. To get a composite total labor supply curve, one need only take a weighted average of these two supply curves. This is done in Figure III-3 in which step-wise elasticities are also calculated. The weights can be either the relative wage bills for each labor type or the relative number of employees of each labor type (i.e., salaried vs. production). The weights used for Figure III-3 are the relative wage bills for the industry as compiled on page one of the questionnaire and from secondary Census and IRS sources.



Elasticities:

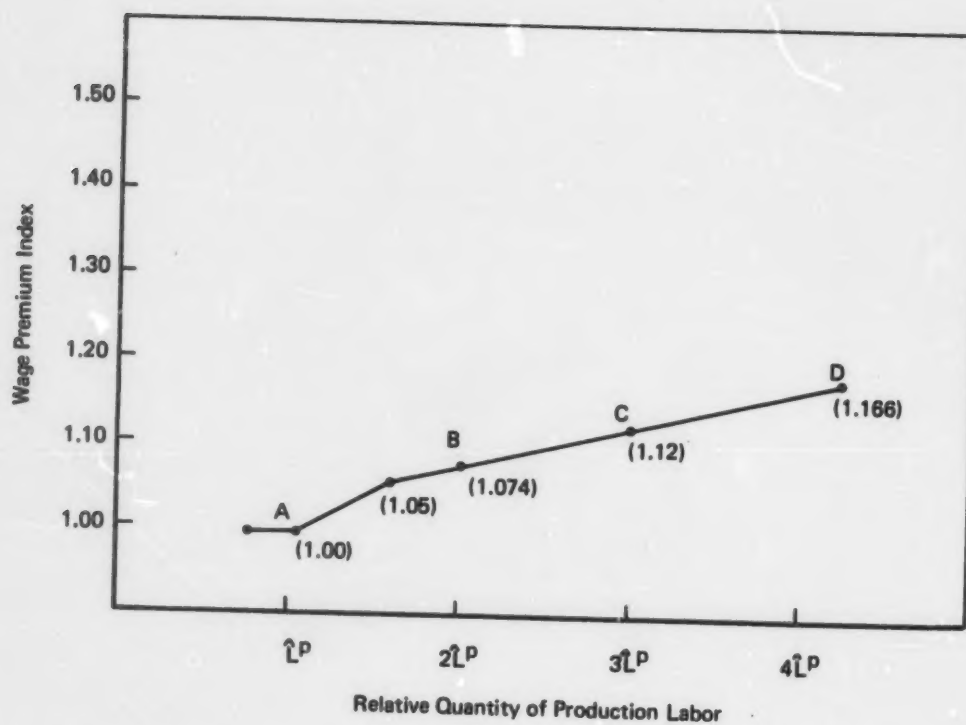
A-B:	8.6
B-C:	5.5
C-D:	3.2

Notes:

$\hat{L}^s$ represents the current level of salaried labor utilization; $2\hat{L}^s$ represents the 200% level, etc.

The Salary Premium Index indicates the salary premium required to obtain additional labor.

**FIGURE III-2 APC AND WPC INSTRUMENTATION INDUSTRY
SUPPLY CURVES OF LABOR
a) Salaried Labor**



Elasticities:

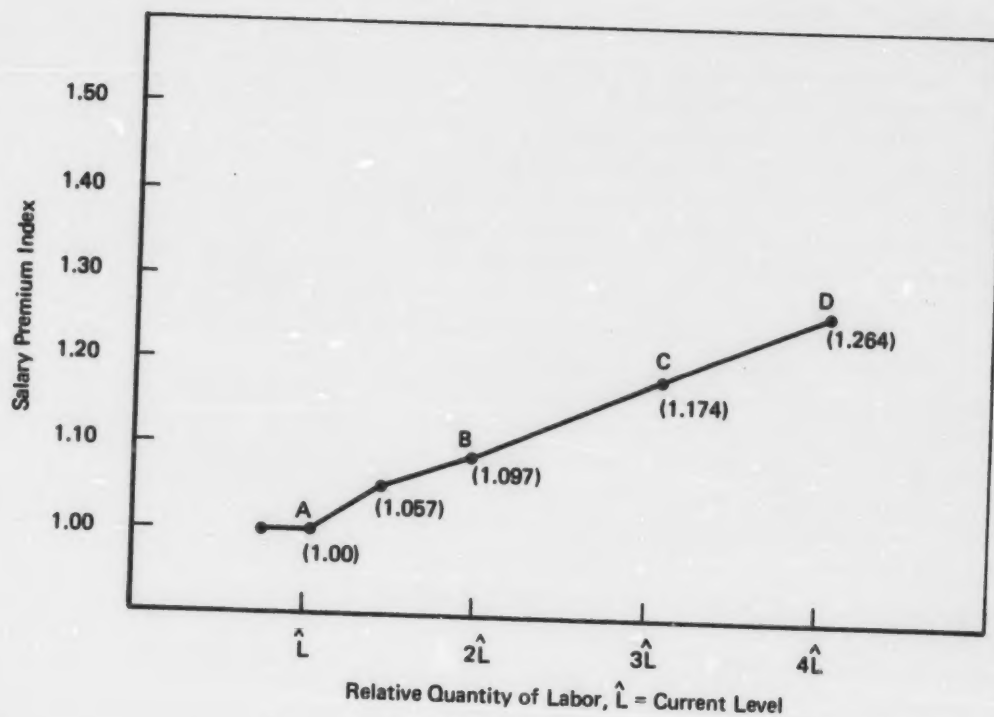
A-B:	13.5
B-C:	11.7
C-D:	8.2

Notes:

$\hat{L}^P$ represents current levels of production labor utilization; $2\hat{L}^P$ represents the 200% level, etc.

The Wage Premium Index indicates the unit wage premium required to obtain additional production labor.

**FIGURE III-2 APC AND WPC INSTRUMENTATION INDUSTRY
SUPPLY CURVES OF LABOR
b) Production Labor**



Elasticities:

A-B:	10.3
B-C:	7.1
C-D:	4.3

Notes:

Relative weights from 1967 Census of Manufactures and industry sources:

Salaried Labor:	.55
Production Labor:	.45

**FIGURE III-3 APC AND WPC INSTRUMENTATION INDUSTRY
Composite Labor Supply Curve**

The labor supply curves listed in Appendix C have all been quantified by this same technique. These supply curves are in essence short-run (annual) supply curves, relating salary premiums against relative increases in labor needs. They have been estimated for 1972. In reality they should be estimated for each year of our analysis. To adequately perform such a labor supply analysis would require a relatively major manpower study. Such a study would investigate proposed manpower training programs over the decade and estimate the output of these programs in terms of trained individuals useful to these industries. It would need to incorporate the reality of the business cycle over the decade as well as competing uses for the specific manpower, especially other pollution-related activities. Our analysis has assumed that the short-run labor supply curves for 1972 to be characteristic of the short-run labor market for each year of the decade. For most of the demand scenarios this is not a serious simplification since increased labor demands range between 5-15% in most years. Our approach has further assumed, moreover, that despite increased hiring each year, the relative premium that a firm must pay for more labor in a given year is the same as that in the preceding year.

These simplifying assumptions become serious only in the Federal Compliance Schedule for the APC industry when demand for labor can increase by 40-60% for three years in a row. In such a case, it could be argued, the labor stock could not reconstitute itself from year to year. Thus, in a given year, supply in general would be much more inelastic than in the preceding year, because the available labor stock was "overdrawn" in the preceding year by the huge demand increases. In these instances, our use of the same 1972 supply curves clearly underestimate the labor inelasticity in multi-year periods of high growth.

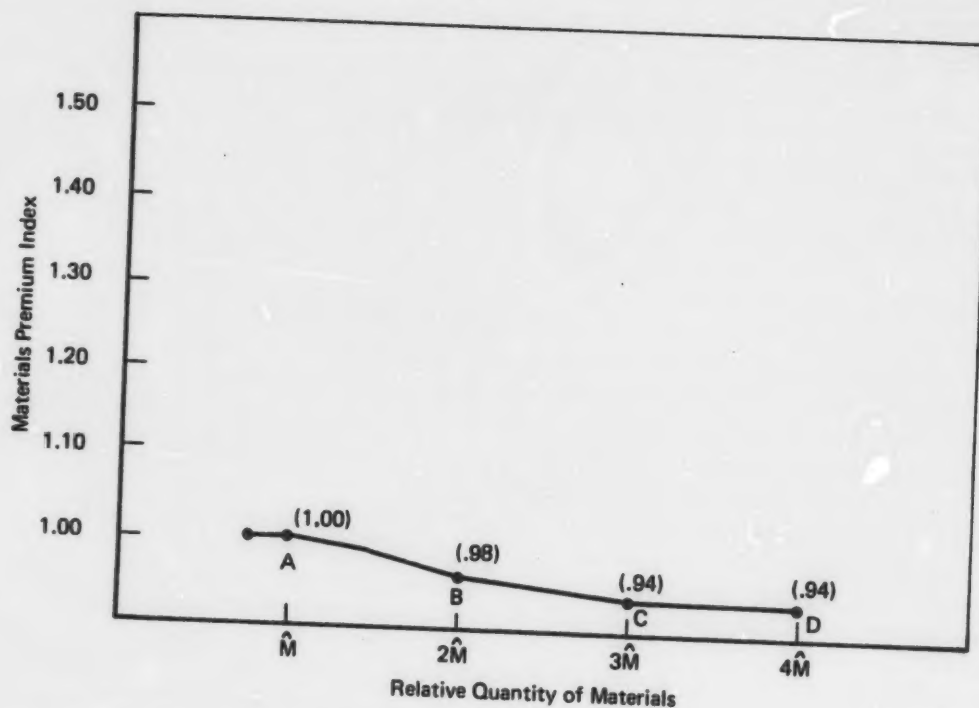
2. Elasticity of Materials Supply

The elasticity of materials supply was also estimated from utilizing the results of the questionnaire (Exhibit C, Appendix C). Supply curves were quantified for the same industry categories that were used in the labor analysis.

- The WPC specialty chemicals industry.
- The WPC specialty equipment industry.
- The particulate and gaseous control equipment industry.
- The APC and WPC instrumentation industry.

The supply curves are generally extremely elastic. In some cases, the resultant supply curves even slope downward, due to anticipated discounts involved with bulk buying or special customer relationships between large pollution abatement firms and their fabricated metals suppliers. The materials supply curves for the WPC equipment industry and for the instrumentation industry slope downward. The supply curve for the APC equipment industry rises very slightly, while that for specialty chemicals also rises. Figure III-4 charts the supply curve for materials in the instrumentation industry. The supply curve slopes downward, reflecting special customer-supplier relationships.

The materials supply curves are charted for each of the industries in Appendix C. As with our labor supply curves, the materials supply curves are based on the 1972 situation relating



Elasticities:

A-B:	-25.0
B-C:	-24.0
C-D:	∞

Notes:

$\hat{M}$ represents current levels of materials utilization; $2\hat{M}$ represents the 200% level, etc.

The Materials Premium Index indicates the unit premium required to obtain additional materials.

**FIGURE III-4 APC AND WPC INSTRUMENTATION INDUSTRY
Materials Supply Curve**

relative increase in materials demanded to relative premium paid per unit of materials. This same short-term supply curve is then assumed to hold for each year over the decade. Given the large capacity of the metal fabricators and the ease of entry into that market, this assumption is fairly acceptable for fabricated inputs. Given the types of raw materials resources needed and their long-run supply availabilities, this assumption is also fairly valid for the raw materials resources.

Finally, Appendix C contains composite supply curves for each of the four industry categories. Such composite curves are the weighted averages of the supply curves for salaried labor, production labor and materials.

3. Elasticity of Capital Supply

a. Particulate Control Equipment

To develop the supply curves for depreciation and borrowed money, we analyzed the aggregate 1968/69 industry income statement and balance sheet for Internal Revenue Service (IRS) SIC code 3560 which includes companies supplying equipment to control particulate emissions. Sensitivity tests were made on this data to determine how much depreciation and interest payments are likely to change as a percent of sales as the industry expands its sales, fixed capital, and current assets.

Assuming a current operating rate of 50% (as reported by the industry) for the particulate control industry, readings on both depreciation and interest payments as a percent of sales were taken at industry sales levels up to four times the base year level, thus encompassing all the levels of demand forecast for the particulate control industry throughout the 1970's in Cases I-III.

Depreciation rates as a percent of sales are plotted in Figure III-5. This chart shows that as the operating rate climbs with rising sales, depreciation drops from about 2.7% of sales to 1.5% of sales for the particulate control industry, on the average. After a 90% operating rate is achieved, depreciation charges remain at 1.5% of sales, assuming the industry continues to operate at about 90% of capacity as demand expands further.

As long as the growth in demand for particulate control equipment does not exceed the initial capacity of the industry to produce, borrowing only occurs to finance current assets. It is assumed that current assets can be financed without paying a premium interest charge. However, as demand for particulate control equipment grows beyond the existing capacity of the industry, expansion of plant and equipment must occur along with the growth of current assets. This means that much larger quantities of money must be obtained either by borrowing or issuing additional stock. Since the average rate of interest charged an industry varies significantly with its financial condition in general and its debt/equity ratio in particular, two assumptions have been made with regard to financing this expansion beyond the industry's current operating rate.

At one extreme, it is assumed that the debt/equity ratio of the industry remains unchanged throughout the expansion of demand. This implies that the industry maintains the same credit rating throughout the forecast period and therefore continues to borrow money at the same interest rate as in the past, on the average. Under this assumption, interest payments remain a constant percent of sales throughout the forecast period. This

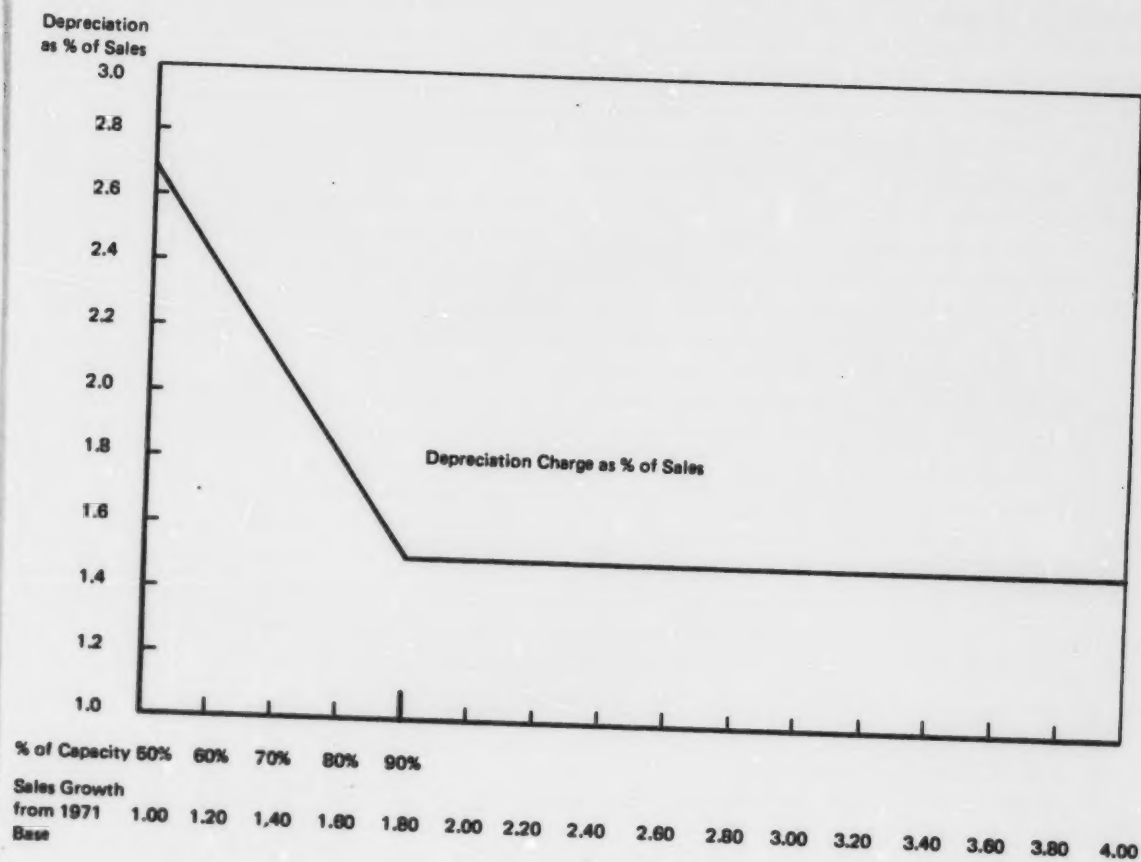


FIGURE III-5 PARTICULATE CONTROL EQUIPMENT
a) Supply Curve for Depreciation

assumption implies an orderly growth in demand and profits, such that the particulate control equipment industry can issue stock in the quantities needed to maintain its debt/equity ratio. At the other extreme, it is assumed that because of a rapid expansion of demand, the industry is forced to borrow to its limit, increasing their debt/equity ratio to 1:1. This high debt/equity ratio requires the maximum interest rate which is assumed to be 10%, on the average. Utilizing these two extreme assumptions, we obtain two levels of interest payments as a percent of sales. In the case of particulate control equipment, the lowest level of interest payments is about 1% of sales and the highest is about 2.6% of sales. These data are shown on Figure III-6. This supply curve for borrowed money is derived from this table in the following way: until a 90% operating rate is reached, the elasticity of supply for borrowed money is infinite, or a straight horizontal line at 1% of sales because the industry does not have to pay a premium rate of interest to finance current assets. After a 90% operating rate is reached, if the industry continues to grow at around 15% per year or less, we assume that interest payments as a percent of sales remain at their historical level of about 1%. However, if, because of a rapid growth in demand for particulate control equipment, the industry is forced to expand capacity at a faster rate, the interest payment as a percent of sales increases. The vertical axis on Figure III-6 shows interest payments as a percent of sales and the percentage growth in sales that is associated with each level of interest payment. The table shows for example that if the industry is operating at 90% of capacity and the growth in demand for particulate control equipment is about 30% in any one year, the interest payment as a percent of sales is likely to be about 1.6% and if the sales growth in any one year is at or exceeds 55%, interest payments as a percent of sales will probably rise to their maximum rate of 2.6% of sales. This chart and other similar ones on interest costs have been used to calculate the cost of interest to the air pollution control equipment industry for the inflationary impact analysis discussed in Part C of this chapter.

b. Gaseous Control Equipment

The supply curves for depreciation and borrowed money for gaseous control equipment suppliers has been calculated in the same manner as for particulate control equipment suppliers. The base statistics used for the gaseous control equipment industry are the aggregate 1968/69 income statement and balance sheets for Internal Revenue Service SIC Code 3440. A current operating rate of 50% has been assumed for suppliers of gaseous emission control equipment, as a true operating rate is difficult to measure in the current developmental stages of this market.

Depreciation declines as a percent of sales from 1.9% to 1% as the gaseous emission control industry moves from 50% of capacity to 90% of capacity. After a 90% operating rate is achieved, depreciation charges remain at 1% of sales assuming the industry continues to operate at about 90% of capacity as demand expands (Figure C-6a, Appendix C).

Interest payments amount to about 1% of sales until the industry reaches an operating capacity of about 90%. As growth in demand exceeds current industry capacity, interest payments as a percent of sales can range from 1% to 2% of sales (Figure C-6b, Appendix C). If the industry is operating at 90% of capacity when sales expand 30% in any one year, the interest payment rises from 1% of sales to 1.4% of sales.

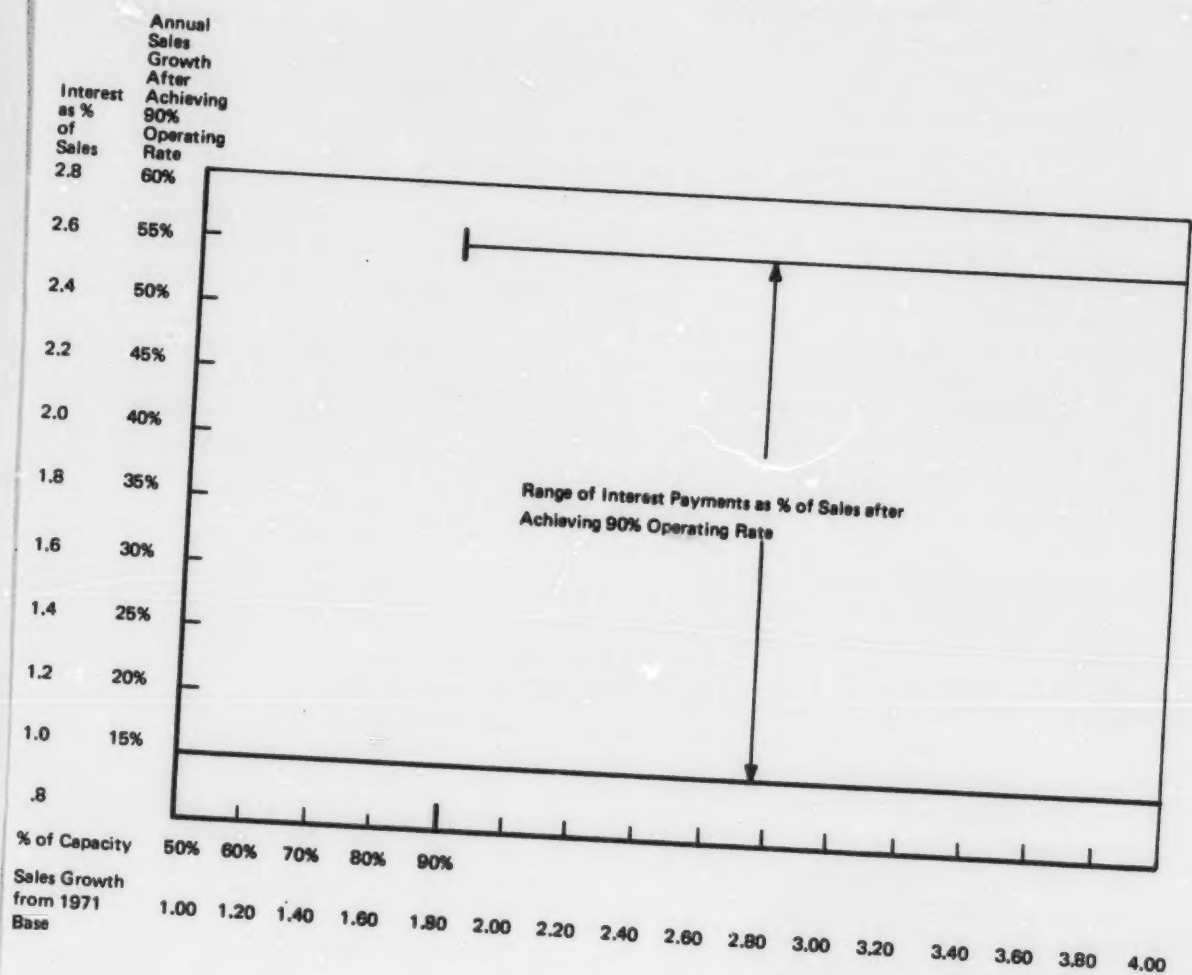


FIGURE III-6 PARTICULATE CONTROL EQUIPMENT
b) Supply Curve for Interest

c. Water Pollution Control Equipment

The supply curves for depreciation and borrowed money for water pollution control equipment suppliers has been calculated in the same manner as for air pollution control equipment. The base statistics used for the water pollution control equipment industry are the 1968/69 aggregate income statement and balance sheets for Internal Revenue Service SIC Code 3580. A current operating rate for plant and equipment of 50% is assumed for suppliers of water pollution control equipment, as has been reported by the industry.

Depreciation drops from 2.2% of sales to 1.0% of sales as the industry reaches operating capacity (Figure C-7a, Appendix C). After a 90% operating rate is achieved, depreciation charges remain at 1% of sales assuming the water pollution control industry continues to operate at about 90% of capacity as demand expands.

Interest payments amount to about 1% of sales until the industry reaches an operating capacity of 90% (Figure C-7b, Appendix C). As growth in demand exceeds current industry capacity, interest payments as a percent of sales can range from 1% to 2.1%. If the industry is operating at 90% of capacity when sales expand 25%, the interest payment rises from 1% of sales to 1.5% of sales.

d. Instrumentation

The supply curves for depreciation and borrowed money for the instrumentation equipment suppliers has been calculated in the same manner as for the air pollution control equipment suppliers. The base statistics used for the instrumentation industry are the aggregate 1968/69 income statement and balance sheet for Internal Revenue Service for SIC Code 3810. A current operating rate of 60% was used for suppliers of APC and WPC instrumentation equipment.

Depreciation declines as a percent of sales from 3.3% to 2.2% as the instrumentation industry moves from a 60% operating rate to a 90% operating rate (Figure C-8a, Appendix C). After a 90% operating rate is achieved, depreciation charges remain at 2.2% of sales assuming the industry continues to operate at about 90% of capacity as demand expands.

Interest payments amount to about 1.1% of sales until the instrumentation equipment industry reaches an operating capacity of about 90% (Figure C-8b, Appendix C). As growth in demand exceeds current industry capacity, interest payments as a percent of sales can range from 1.1% to 3.0%. The following example shows how the chart should be used: If the industry is operating at 90% of capacity, when sales expand 25% in any one year, the interest payment as a percent of sales rises from 1.1% to 1.8%.

e. Specialty Chemicals

The supply curves for depreciation and borrowed money for specialty chemical suppliers has been calculated in the same manner as for the air pollution control equipment suppliers. The base statistics used for the specialty chemicals industry are the aggregate 1968/69 income statement and balance sheet for Internal Revenue Service SIC Code 2898. A current operating rate of 60% is assumed for suppliers of specialty chemicals.

Depreciation declines as a percent of sales from 3.9% to 2.6% as the specialty chemical industry moves from a 60% operating rate to a 90% operating rate (Figure C-9a, Appendix C). After a 90% operating rate is achieved, depreciation charges remain at 2.6% of sales

assuming the industry continues to operate at about 90% of capacity as demand expands.

Interest payments amount to about 1.4% of sales until the specialty chemicals industry reaches an operating capacity of about 90% (Figure C-9b, Appendix C). As growth in demand exceeds current industry capacity, interest payments as a percent of sales can range from 1.4% of sales to 2.8% of sales. If the industry is operating at 90% of capacity when sales expand 15% in any one year, the interest payment as a percent of sales rises from 1.4% to 2.0%.

C. PRICE EFFECTS

I. Methodology

The inflationary impact of pollution control differs with the segment of the market, i.e., air, water, instrumentation or specialty chemicals and the timetable assumed for compliance. If the companies in a market segment tend to manufacture primarily pollution abatement equipment, that segment will be more affected by inflationary pressure than if a boarder line of products is manufactured. Generally, if the Federal Compliance Schedule or Case II is assumed, demand for pollution control equipment rises more sharply in the first half of the 1970's than in our Estimated Compliance Schedule or Case III. As a result, greater inflationary pressure will be exerted on the economy under Case II than under Case III through 1975.

In order to determine the magnitude of the inflationary impact in each market under different enforcement timetables, we developed supply curves for each major cost of production: materials, skilled labor, production labor, and interest. These supply curves have been discussed in Section B of this chapter. In this section, we show how we use these supply curves to determine the potential effect of different rates of increase in demand on the cost of pollution abatement equipment. To describe this potential impact on the price of pollution abatement equipment, we use Particulate Control - Case II(a) - as an example.

Rows 1, 4, 7, 10, 13, 16, 19, 22, 25 and 28 of Column 2, Table III-1 show the base demand for particulate control equipment in millions of 1972 dollars from 1971 to 1980 which is likely to prevail if the Federal Compliance Schedule is followed.

Column 3 shows the annual percent change in demand for particulate control equipment from 1971 through 1980. It is clear that to meet the Federal Compliance Schedule, the industry will be forced to expand very rapidly through 1975 after which demand will fall off substantially.

a. Materials Costs Effect

Columns 4 and 5 show our analysis of materials requirements. We assume that materials are bought as required so the operating rate (or OR as shown in the table) for materials is at design capacity (or 90% as shown in the table). The 1967 *Census of Manufactures* reports that the cost of materials is approximately 42% of sales in the four-digit industry encompassing particulate control equipment (S.I.C. No. 3564) (See Table III-2.). This percentage was checked by phone with the actual breakdowns of producers. Both the operating rate and the percentage of sales are shown under Columns 4 and 5 directly beneath the heading "Materials" in Table III-1.

TABLE III-2

COSTS AS A PERCENTAGE OF NET SHIPMENTS - 1967

	<u>SIC</u>	<u>Materials</u>	<u>Labor</u>		<u>Other</u>
			<u>Prod.</u>	<u>Skilled</u>	
Particulate Removal	3564	42	17	11	30
Gaseous Control	3443 ¹	50	18	8	24
WPC Equipment	35851 ²	54	13	10	23
Instrumentation	38213	34	18	22	44
Specialty Chemicals	28993	47	6.5	9.5	37

¹The emerging industry of gaseous control was actually simulated as a 50:50 mix of SIC Nos. 3564 and 3443 when using the cost mixes in the impact analysis.

²Although the bulk of the water pollution control equipment more logically fits in SIC No. 35892 (Service Industry Machines), information from specific companies indicated that the material and labor components of total revenues were more similar to SIC No. 35851 (Heat Transfer Equipment).

SOURCE: *Census of Manufactures.*

Rows 1, 4, 7, 10, 13, 16, 19, 22, 25, and 28 of Column 4 show what the industry would pay for materials in each year of the forecast period in millions of 1972 dollars if materials were readily available to supply all the industry's needs. The cost of materials under this assumption is calculated by taking 42% of the base demand in each year of the forecast period because 42% is materials' initial share of total sales. However, when demand in a single year increases 46% as it does in 1973 (Row 7, Column 3), producers in the industry have indicated that the cost of materials is likely to rise. The relative increase in the cost of materials associated with each change in demand is described by the supply curve for materials (Figure C-1c) in the particulate control segment of the market shown in an appendix to this report. This supply curve shows that a 46% increase in demand is associated with a 1.005 index point increase in the cost of materials (Row 7, Column 5). The 1.005 is multiplied by the uninflated base materials cost in 1973 or 151.6 million 1972 dollars (Row 7, Column 4) to arrive at the inflated cost the industry probably will have to pay for materials in 1973. The cost after adjustment for the upward slope in the supply curve is 152.4 million 1972 dollars (Row 8, Column 4). To determine the total cost effect of this inflation factor, we subtract 151.6 from 152.4 and divide the resulting 0.8 million 1972 dollars (Row 9, Column 4) by base demand in 1973, which is 361 million 1972 dollars (Row 7, Column 2). The materials cost effect is 1.0022 (Row 9, Column 5). It shows the proportionate potential effect on price of the increased cost of materials due to the rising supply curve.

To determine the materials cost effect for 1974, we first note that the annual growth in demand for particulate control equipment is 58% in that year (Row 10, Column 3). Our materials supply curve indicates that this would likely result in a 1.010 index point increase in the cost of materials (Row 10, Column 5). To obtain the full impact of increased materials costs in 1974, however, it is necessary to accumulate the inflation occurring in 1973 and the inflation occurring in 1974. To do this we multiply the cumulative inflation factor in 1973 (1.005) Row 8, Column 5, by the inflation factor in 1974 (1.010) Row 10, Column 5 to obtain the cumulative inflation factor for 1975 - 1.1015 (Row 11, Column 5). The cumulative inflation factor is multiplied by the base materials cost - 239.4 million 1972 dollars (Row 10, Column 4) to obtain the inflated materials cost for that year - 243.0 (Row 11, Column 4). The inflationary effect of the 58% increase in demand for particulate control equipment on materials costs in 1974 is determined by subtracting 239.4 from 243.0 to obtain 3.6 million 1972 dollars (Row 12, Column 4). The potential cost effect on price is obtained by dividing 3.6 by base demand in 1974 - 570 million 1972 dollars (Row 10, Column 2). This inflationary cost effect is 1.0063 (Row 12, Column 5). The materials cost effect for subsequent years is calculated in the same manner as described for 1974. When demand for particulate equipment declines as it does after 1975 (Column 3), the inflation factor on materials costs drops back to 1.000 (Row 17, Column 5) because material suppliers are then expected to be operating below capacity.

b. Skilled Labor Costs Effect

Turning now to skilled labor, our interviews of producers of particulate control equipment indicate that the operating rate for skilled labor is probably about 60%. The *Census of Manufactures* reports that the skilled labor payroll amounts to about 11% of

sales in a somewhat broader industry (Table III-2). This portion agrees with responses obtained from companies producing particulate control equipment. Since skilled labor is being under-utilized until mid-1973, there is no need to hire additional skilled personnel until that time. As a result, the cost of skilled labor as a percentage of sales declines through 1973 from 11% to 7% as the industry moves up to its most efficient operating rate, or 90% of capacity. The base cost for skilled labor throughout the forecast period, assuming no inflationary pressure, is shown in rows 1, 4, 7, 10, 13, 16, 19, 22, 25, and 28 of Column 6. This base cost of skilled labor would prevail were the supply curve completely flat. To determine the base cost of skilled labor we have assumed that while the industry is operating near capacity, i.e., from 1973-1975, the skilled labor component is 7% of base demand and in periods of substantial excess capacity - i.e., from 1971-1972 and 1976-1980, the skilled labor component is 11% of base demand.

Since the supply curve for skilled labor, according to producers of particulate control equipment is not flat, when demand increases 46% in 1973 (Row 7, Column 3), the cost of skilled labor is likely to rise to 1.120 index points (Row 7, Column 7). Since there has not been any previous inflation, the cumulative inflation factor for skilled labor in 1973 is also 1.120 (Row 8, Column 7). To determine the effect of this cost increase on the skilled labor payroll, the inflation factor for skilled labor (Row 8, Column 7) is multiplied by the base cost - 26.3 million 1972 dollars (Row 7, Column 6) to obtain the inflated cost of 29.46 million 1972 dollars (Row 8, Column 6). To obtain the effect of this inflation in dollars we subtract the base dollar cost of skilled labor - 26.3 (Row 7, Column 6) from the inflated dollar cost - 29.46 (Row 8, Column 6) which gives us 3.16 million 1972 dollars (Row 9, Column 6). The proportional inflationary impact of this cost increase on price is determined by dividing the 3.16 by the base demand in 1973 of 361 million 1973 dollars (Row 7, Column 2). The potential impact of the rising skilled labor supply curve on prices is an index of 1.0088 in 1973 (Row 9, Column 7).

The 1974 inflation factor is calculated in the same way for skilled labor as it is for materials. Our labor supply curve shows that with the 58% increase in base demand occurring from 1973 to 1974 (Row 10, Column 3) the cost of skilled labor is likely to rise 1.125 index points (Row 10, Column 7). This inflation factor for 1974 is then multiplied by the cumulative inflation factor for 1973 of 1.120 (Row 8, Column 7) to obtain a cumulative inflation factor of 1.260 (Row 11, Column 7) for 1974. This cumulative inflation factor is multiplied by the base cost of skilled labor in 1974 - 41.52 million 1972 dollars (Row 10, Column 6) to obtain the inflated labor cost in 1974 of 52.32 million 1972 dollars (Row 11, Column 6) for the industry due to pressure on skilled labor availability. The differential between the inflated cost (Row 11, Column 6) and the base cost (Row 10, Column 6) is 11.8 million 1972 dollars (Row 12, Column 6). When 11.8 is divided by the base demand of 570 million 1972 dollars (Row 10, Column 2), the inflationary impact of the rising cost of skilled labor on price of 1.0207 index points is obtained for 1974 (Row 12, Column 7). For subsequent years, the index of the inflationary pressure from the rising cost of skilled labor on price is obtained in the same manner as described for 1974. As the demand for particulate control equipment declines in the latter half of the decade, the index of the inflationary impact of the rising cost of skilled labor on price declines (Rows 21, 24, 27, and 30 of Column 7) as skilled labor becomes more readily available to those remaining in the

industry. In lieu of specific data on the slope of the supply curve on the downside, we have assumed a reasonable annual "deflation" of 0.5% or an index of 0.95. This trend prevails until a cumulative index of 1.000 is achieved again.

c. Production Labor Costs Effect

The operating rate for production labor is assumed to be 90%. According to the *Census of Manufactures*, production labor amounts to 17% of sales (Table III-2). This percentage as well as our operating rate assumption were checked with companies in the particulate control business. The base cost of production labor was held at 17% of sales throughout the forecast period. In 1972, when demand for particulate equipment increases 23% (Row 4, Column 3), our supply curve for production labor shows that the cost of such manpower will rise 1.060 index points (Row 4, Column 9). Since there has been no previous inflation factor for production labor, the cumulative inflationary cost effect in 1972 is also 1.060 (Row 5, Column 9). This cumulative inflation factor is multiplied by the base cost of production labor - 41.7 million 1972 dollars (Row 4, Column 8) to obtain the inflated cost in 1972 of 44.2 million 1972 dollars (Row 5, Column 8). Subtracting the inflated cost of 44.2 from the base cost of 41.7 we get 2.5 million 1972 dollars (Row 6, Column 8). Dividing the 2.5 million 1972 dollars (Row 6, Column 8) by the base demand in 1972 of 247 million 1972 dollars (Row 4, Column 2) yields an index of 1.0101 (Row 6, Column 9), which is the inflationary pressure on price in 1972 due to the rising supply curve for production labor.

The inflationary impact on price for 1973 is calculated in the same manner. The supply curve for production labor indicates that a 46% growth in demand for particulate control equipment (Row 7, Column 3) results in a 1.125 index point increase in production labor costs (Row 7, Column 9). This inflation index for 1973 is multiplied by the cumulative index for 1972 of 1.060 (Row 5, Column 9) to obtain the cumulative inflation factor for 1973 of 1.193 (Row 8, Column 9). The cumulative inflation factor is multiplied by the base production labor cost of 61 million 1972 dollars (Row 7, Column 8) to obtain the inflated production labor cost of 72.8 million 1972 dollars (Row 8, Column 8). The differential between the base cost and the inflated costs is 11.8 million 1972 dollars (Row 9, Column 8). The 11.8 million differential is divided by the base demand in 1973 of 361 million 1972 dollars (Row 7, Column 2) to obtain the inflationary impact on price in 1973 of the rising supply curve for production labor of 1.0327 index points (Row 9, Column 9). The inflationary pressure in subsequent years is calculated in the same manner.

As demand for particulate equipment declines in the latter half of the decade, no new production labor will be needed, so the inflation factor for any one year is 1.000. However, the cumulative inflation built up during years of sharply rising demand will continue to affect producers because of labor union contracts, etc. Hence, the impact on price of the inflated cost of production labor remains at a constant level of 1.0873 from 1974 to 1980 (Rows 15, 18, 21, 24, 27, and 30 of Column 9).

d. Capital Costs Effect

Interest payments depend on the operating rate for the capital employed in the particulate control business. Producers indicate that the industry is currently operating at

50% of physical plant and equipment. Interest payments amount to about 1% of the industry's sales (Figure C-5B, Appendix C). The base cost of interest payments is 1% of base demand throughout the forecast period. While the industry is operating below capacity interest costs increase about in line with sales because borrowing occurs only to finance current assets. When the industry reaches capacity, additional increases in demand must be financed by longer term borrowing for expansion of plant and equipment. When demand increases sharply forcing an increase in the debt/equity ratio, the supply curve of borrowed money rises, as the analysis in Section A of this chapter shows.

In 1974 the particulate control industry reaches productive capacity. Demand in that year increases by 58% (Row 10, Column 3). In order to borrow money to finance this expansion, interest payments will rise by an inflation factor of 2.596 index points (Row 10, Column 11). In order to finance this rate of expansion, the industry would have to pay 10% for long-term money, on the average. Currently the industry is paying about 6%. Since there is no cumulative inflation factor from previous years, the cumulative inflation for 1974 for interest payments is also 2.596 (Row 11, Column 11). This number is then multiplied by the base interest cost of 5.7 million 1972 dollars (Row 10, Column 10) to obtain the inflated cost of interest in 1974 of 14.8 million 1972 dollars (Row 11, Column 10). Subtracting 14.8 from 5.7 gives the increased cost of interest due to higher rates of interest and higher levels of borrowing of 9.1 million 1972 dollars (Row 12, Column 10). Dividing 9.1 by the base demand of 570 million 1972 dollars in 1974 (Row 10, Column 3) gives the inflationary effect on price of the increased interest payments in 1974 of 1.0160 index points (Row 12, Column 11).

In 1975, in order to produce 64% more particulate control equipment, the industry must again borrow money at top interest rates. As a result, the cumulative inflation factor for 1975 is the same as the previous year. The 1975 cumulative inflation factor (Row 14, Column 11) is multiplied by the base interest cost in 1975 of 9.4 million 1972 dollars (Row 13, Column 10) to obtain the inflated interest cost of 24.3 million 1972 dollars (Row 14, Column 10) for 1975. The differential between 24.3 and 9.4 is 14.9 million 1972 dollars (Row 15, Column 10) which is the added cost of interest in 1975 due to the inflation factor. The 14.9 is divided by 935 (Row 13, Column 2) the base demand in 1975 to obtain the cost effect on price of this inflated interest charge - 1.0159 (Row 15, Column 11).

In 1976, as the industry's operating rate drops and the pressure is off the money markets, companies will refinance their interest charges as quickly as possible to obtain a lower rate. As a result, the inflation factor for 1976 is only .618 (Row 16, Column 11) which, when multiplied by the cumulative inflation factor in 1975 of 2.596 (Row 14, Column 11) results in a decrease in the cumulative inflation factor for 1976 to 1.604 (Row 17, Column 11). This cumulative inflation factor is multiplied by the 1976 base interest charges of 5.3 million 1972 dollars (Row 16, Column 10) to get the inflated interest charge of 8.5 million 1972 dollars (Row 17, Column 10). The differential between these two numbers is 3.2 (Row 18, Column 10) which is divided by base demand of 530 million 1972 dollars (Row 16, Column 2) to obtain the cost effect on price of 1.0060 (Row 18, Column 11) due to inflation in 1976 interest payments. By 1977 the industry is expected to be able to refinance all borrowed monies at the interest rates prevailing under conditions of normal demand. Hence, the cumulative inflation factor for interest in 1977 is reduced to 1.000

(Row 20, Column 11) and there is no inflationary pressure on price from interest payments in that year. Demand continues to decline throughout the rest of the decade, so no additional plant capacity will be needed and there will be no further pressure on price from excessive interest payments.

Since the charge for depreciation generally represents either a declining or a constant cost to the industry as a percent of sales (See Section B of this chapter) it has not been included in this analysis because it will not put any inflationary pressure on price. However, when demand is declining, there is a possibility that depreciation charges, industry-wide, may rise as a percent of sales. The extent to which this will occur cannot be measured, however, because it is not certain whether on balance the industry will adjust to declining demand by accepting a very low operating rate with all firms staying in business or whether a large number of companies will leave the industry permitting those who remain to maintain reasonable operating rates. Since the range of combinations in between these two extremes is very great, no attempt has been made to impute their effects upon price.

In addition, there are other costs of doing business besides those which have been specifically analyzed here. However, since they differ greatly from company to company, these costs have not been quantified. It can generally be assumed that most of the other costs are fixed and hence would behave in a manner similar to depreciation.

e. Cumulative Costs Effect

Column 13, which shows the total cost pressure on price, is obtained by summing the cost effect indexes for each production cost for each year. For example, the total cumulative index in 1974 of 1.1007 (Row 11, Column 13) is the sum of the materials cost effect index in of 1.0063 (Row 12, Column 5), the skilled labor cost effect index in 1974 of 1.0207 (Row 12, Column 7), the production labor cost effect index in 1974 of 1.0577 and the interest cost effect index in 1974 of 1.0160 (Row 12, Column 11). The cumulative index for all other rows has been determined in exactly the same manner. The index numbers in Column 12 are the year-to-year changes in the cumulative cost effects shown in Column 13. For example, the 1.0333 in Row 8, Column 12 is obtained by dividing 1.0437 (Row 8, Column 13) by 1.0101 (Row 5, Column 13).

The cumulative cost data shown in Column 13 can be used to calculate the accumulated inflationary impact of increased factor costs upon the national bill for pollution control equipment, assuming these cost effects are passed on in the form of price increases. We do this by multiplying the cumulative index for each year times the base demand for each year. For example, in 1972, 1.0101 (Row 5, Column 13) is multiplied by 247 million 1972 dollars (Row 4, Column 2) to obtain the inflated demand of 249.5 million 1972 dollars (Row 5, Column 2). Similarly, in 1973, the 1.0437 (Row 8, Column 13) is multiplied by 361 million 1972 dollars (Row 7, Column 2) to obtain the inflated demand of 376.8 million 1972 dollars (Row 8, Column 2).

After determining the inflated demand for each year, we can then determine the inflationary impact of enforcing the Federal Compliance Schedule for particulate control. This is done by summing the inflated demand from 1971-1980 and dividing by the sum of the base demand over the same period. This gives us the average inflationary differential caused by cost increases in key factors of production in the 1970's. This cumulative

inflation, which in the case of particulate control amounts to 10.3% over the forecast period (bottom of Table III-1) can be reinterpreted to an average annual rate of inflation over 9 years.

It is important to note that this rate of inflation results solely from the industry passing on all its added costs. It is conceivable that in reality, in some year the industry will absorb some of its costs and in other years prices will rise faster so as to enable the industry to increase its profit margin.

2. Discussion of Results

a. Air Pollution Control Equipment

Comparing the inflationary impact of the Federal Compliance Schedule (Case II) with the Expected Compliance Schedule (Case III) shows clearly that the former has a greater inflationary impact on the national bill for air pollution control equipment. (See Tables III-3 and III-4). The tables show the potential cost effects on price (i.e., the cost increases which could potentially be passed on in higher prices) of Cases II and III for both particulate control and gaseous control equipment. Under Case II, the cumulative index rises much faster in the first half of the 1970's as the industry is pushed hard to meet a rapidly expanding demand. Even though demand drops in the second half of the decade under Case II, the industry cannot rid itself completely of these extra costs by 1980.

The effects of assuming (b) that adequate gaseous control technology is available vary between the particulate and gaseous control segments. If proven SO₂ control technology is available, of course the rate of gaseous control activity increases in both Cases II and III and the cost push inflation increases, too (Table III-4). Particulate control activity, however, is reduced with this assumption, (b), and with it, inflation effects are reduced as well in that market segment (Table III-3).

These are, of course, industry-wide statistics. Not all the companies in the industry will experience the same pressures on costs and prices. Suppliers with a reputation for quality will probably experience a much greater demand pressure because many commercial and industrial firms installing the equipment will want to be assured of proper functioning and will be willing and able to pay extra for that assurance. Smaller companies and those less experienced in manufacturing air pollution control equipment may experience greater cost increases (due to inefficiencies) than the industry average. Such companies will either have to operate at profit margins below the industry average or find relatively uncompetitive markets in which to sell their equipment.

b. Water Pollution Control Equipment

Both the relative and absolute impact of the Federal Compliance Schedule is not nearly as great in water pollution as in air pollution. The average price increase incurred by the water pollution control equipment industry to cover added costs under Case II is only 0.8% and only 0.3% under Case I and III (See Table III-5).

The impact of the pollution abatement program on companies in this industry is dampened because most of these companies also manufacture water treatment equipment. This eases their problems in gearing up to service the pollution abatement market since

TABLE III-3
COMPARATIVE INFLATIONARY IMPACT OF CASES II AND III -- AIR POLLUTION CONTROL
PARTICULATE CONTROL EQUIPMENT

		<u>Case II - Federal Compliance Schedule</u>		<u>Case III - Expected Compliance Schedule</u>	
		<u>(a) Present Gaseous Control Technology</u>	<u>(b) Adequate Gaseous Control Technology</u>	<u>(a) Present Gaseous Control Technology</u>	<u>(b) Adequate Gaseous Control Technology</u>
		<u>Cumulative Index</u>	<u>Cumulative Index</u>	<u>Cumulative Index</u>	<u>Cumulative Index</u>
1972		1.0101	1.0018	1.0033	1.0027
1973		1.0437	1.0048	1.0060	1.0072
1974		1.1007	1.0245	1.0146	1.0171
1975		1.0443	1.0733	1.0213	1.0223
1976		1.1395	1.0699	1.0279	1.0260
1977		1.1258	1.0565	1.0309	1.0238
1978		1.1192	1.0500	1.0377	1.0213
1979		1.1115	1.0443	1.0472	1.0213
1980		1.1049	1.0413	1.0527	1.0213
Inflated Demand					
1971-1980 (Millions					
1972 Dollars)		\$3794.3	\$2262.4	\$3337.8	\$2212.2
# Base Demand					
1971-1980 (Millions					
1972 Dollars)		\$3439.0	\$2178.0	\$3244.0	\$2176.0
= Average					
Inflation		10.3%	3.9%	2.9%	1.7%

TABLE III-4
COMPARATIVE INFLATIONARY IMPACT OF CASES II AND III -- AIR POLLUTION CONTROL
GASEOUS CONTROL EQUIPMENT

Case II - Federal Compliance Schedule		Case III - Expected Compliance Schedule	
(a) Present Gaseous Control Technology	(b) Adequate Gaseous Control Technology	(a) Present Gaseous Control Technology	(b) Adequate Gaseous Control Technology
Cumulative Index	Cumulative Index	Cumulative Index	Cumulative Index
1972 1.0094	1.0080	1.0044	1.0110
1973 1.0240	1.0395	1.0104	1.0222
1974 1.0691	1.0893	1.0176	1.0536
1975 1.1089	1.1363	1.0251	1.0730
1976 1.1552	1.1911	1.0420	1.0966
1977 1.1658	1.1990	1.0596	1.1267
1978 1.1530	1.1852	1.0847	1.1723
1979 1.1455	1.1772	1.0965	1.1793
1980 1.1380	1.1694	1.1167	1.1794
Inflated Demand			
1971-1980 (Millions			
1972 Dollars) \$1176.2	\$2084.7	\$1054.5	\$1888.8
‡ Base Demand			
1971-1980 (Millions			
1972 Dollars) \$1051.0	\$1799.0	\$ 988.0	\$1664.0
= Average Inflation	11.9%	6.7%	13.5%

TABLE III-5

COMPARATIVE INFLATIONARY IMPACT OF CASES I, II AND III
WATER POLLUTION CONTROL EQUIPMENT

	<u>Case I</u>	<u>Case II</u>	<u>Case III</u>
	<u>Baseline</u>	<u>Federal Compliance Schedule</u>	<u>Expected Compliance Schedule</u>
	<u>Cumulative Index</u>	<u>Cumulative Index</u>	<u>Cumulative Index</u>
1972	1.0007	1.0013	1.0006
1973	1.0013	1.0026	1.0013
1974	1.0020	1.0046	1.0026
1975	1.0026	1.0090	1.0038
1976	1.0033	1.0131	1.0054
1977	1.0039	1.0141	1.0054
1978	1.0046	1.0100	1.0054
1979	1.0053	1.0087	1.0054
1980	1.0060	1.0087	1.0059
Inflated Demand 1971-1980 (Millions 1972 Dollars)	\$1909.4	\$3677.0	\$3648.0
+ Base Demand 1971-1980 (Millions 1972 Dollars)	\$1903.0	\$3655.4	\$3636.0
= Average Inflation	0.3%	0.8%	0.3%

water treatment equipment amounts to about half the sales of the industry. The fact that municipalities represent about half of the market for water pollution control equipment is also expected to mitigate inflationary pressure. It is considered likely that many equipment suppliers will absorb some of their increased costs when bidding for municipal work just to ensure that they under-bid competition and get the contract.

c. APC and WPC Instrumentation

The rapid growth required of the instrumentation companies to meet the Federal Compliance Schedule results in a 4.6% inflation due to cost increases in the factors of production (See Table III-6). Under the Expected Compliance Schedule, the average cost increase which could potentially be passed on in higher prices is around 2.3%. Most of the cost increases in this market are due to the phasing of the growth in air pollution control activity.

Specialty Chemicals

The inflationary impact of rising costs on the specialty chemicals segment of the market is a very low 0.2%, on the average, from 1971-1980. (See Table III-6). In this market we expect suppliers to have no trouble meeting the Federal Compliance Schedule, so Case II is practically synonymous with Case III.

Specialty chemical producers will be less affected by the pollution abatement program because most of these companies are more heavily in other markets such as water treatment chemicals.

D. EMPLOYMENT EFFECTS

The number of people employed in the pollution control industry can vary widely depending upon the enforcement strategy, i.e., Baseline (Case I), Federal Compliance Schedule (Case II), and Expected Compliance Schedule (Case III). Short of a larger study which would accurately detail the kinds of manpower needs, we have calculated the gross level of employment implied in the demand projections.

Tables C-11 through C-15 included in Appendix C detail the sales dollars per employee for selected companies in various pollution control categories. The averages for these companies are presented in Table III-7. Where a company showed an unusual ratio as compared to the rest of the industry, the company was excluded from the averages. For example, Research-Cottrell showed a sales/employee figure well above the others in its category. Further investigation showed that this company contracts out most of its field erection work and does not carry these employees on its payroll.

For each of the industries, the sales of equipment and associated services were combined from the ADL demand analysis. These numbers are displayed on Table III-8. From these total sales numbers the number of employees was calculated by dividing the total sales by the previously determined sales/employee ratios. Three years were considered: 1972, 1975, and 1980. Table III-8 lists the total employees needed across the five industries for each demand case. Not surprisingly Case II shows a rise in total employment from 38,000 in 1972 to 100,000 in 1975 and a plunge to 27,000 in 1980. Case I, the base line, shows only a

TABLE III-6

COMPARATIVE INFLATIONARY IMPACT OF CASES II AND III
INSTRUMENTATION AND SPECIALTY CHEMICALS

	<u>Instrumentation</u>		<u>Specialty Chemicals</u>
	<u>Case II</u>	<u>Case III</u>	<u>Case III (and II)</u>
	<u>Federal Compliance</u> <u>Schedule</u>	<u>Expected Compliance</u> <u>Schedule</u>	<u>Expected and Federal</u> <u>Compliance Schedules</u>
	<u>Cumulative Index</u>	<u>Cumulative Index</u>	<u>Cumulative Index</u>
1972	1.0073	1.0036	1.0003
1973	1.0294	1.0063	1.0006
1974	1.0494	1.0129	1.0009
1975	1.0699	1.0225	1.0012
1976	1.0599	1.0253	1.0016
1977	1.0554	1.0287	1.0020
1978	1.0472	1.0287	1.0031
1979	1.0353	1.0312	1.0038
1980	1.0284	1.0355	1.0045
Inflated Demand 1971-1980 (Millions 1972 Dollars)	\$1175.3	\$1144.0	\$3466.0
+ Base Demand 1971-1980 (Millions 1972 Dollars)	\$1123.0	\$1118.0	\$3459.0
= Average Inflation	4.6%	2.3%	.2%

small increase in employees from 21,000 in 1972 to 31,000 in 1980 while Case III shows a steady increase from 35,000 in 1972 to 75,000 in 1980.

While the present over-capacity in the industry and an increase in productivity over time may cause the above figures to be somewhat overstated, the relative differences among the three cases would not change significantly.

TABLE III - 7

NET SALES/EMPLOYEE AVERAGES

(Thousands of Dollars/Employee)

	<u>"In"</u>	<u>"Near"</u>
APC Equipment - Particulate	30.1	34.6
APC Equipment - Gaseous	-	32.4
WPC Equipment	32.5	35.5
Instrumentation	20.9	20.9
WPC - Specialty Chemicals	41.0	36.8

SOURCE: Arthur D. Little, Inc., estimates.

TABLE III-8

INDUSTRY PERSONNEL REQUIREMENTS, COMPARISON OF THREE CASES, 1972-80

Industry Category	Case	1972			1975			1980		
		I	II	III	I	II	III	I	II	III
		And \$M Sales/ Employee Ratio								
APC Equipment- Particulate*	Sales (\$MM)	207	449	389	242	1,693	563	312	142	854
30.1	Employee	6,880	14,900	12,900	8,040	56,200	18,700	10,400	4,700	28,400
APC Equipment- Gaseous*	Sales	30	100	91	34	328	153	44	182	546
32.4	Employee	926	3,090	2,800	1,050	10,100	4,720	1,360	5,610	16,850
WPC Equipment- 32.5	Sales	159	318	298	183	531	399	236	136	366
	Employee	4,890	9,780	9,170	5,630	16,300	12,300	7,260	4,180	11,300
Instrumentation 20.9	Sales	14	80	69	38	198	109	50	45	166
	Employee	1,630	3,830	3,300	1,900	9,470	5,220	2,390	2,150	7,900
WPC-Spec.Chem. 41.0	Sales	282	289	289	318	339	336	392	419	418
	Employee	6,880	7,050	7,050	7,760	8,270	8,200	9,560	10,200	10,200
Total Employees		21,200	38,650	35,220	24,280	100,340	49,140	30,970	26,840	74,650

* Corresponds to demand projections for APC equipment in situation (a) assuming continued technological difficulties in candidate SO₂ control technologies.

SOURCE: Arthur D. Little, Inc. estimates.

APPENDIX A - FOR CHAPTER I

TABLE A-1
MAJOR COMPANIES IN AIR AND WATER POLLUTION CONTROL

Parent Company and Location	Divisions or Subsidiaries	<u>Air</u>		<u>Water</u>		
		Equipment	Instruments	Equipment	Instruments	Chemicals
American Air Filter Louisville, Ky.		x				
American Standard New York, N.Y.		x		x		
Automated Environmental Systems Woodbury, L.I., N.Y.			x		x	
Babcock & Wilcox New York, N.Y.		x				
Beckman Instruments Fullerton, Calif.			x		x	
Bendix Southfield, Mich.			x		x	
Betz Laboratories Trevose, Pa.					x	x
Bird & Son East Walpole, Mass.	Bird Machine			x		
Boise Cascade Boise, Idaho	Chemico	x				
Buckman Laboratories Memphis, Tenn.						x
Buffalo Forge Buffalo, N.Y.		x				

Parent Company and Location	Divisions or Subsidiaries	Air		Water		
		Equipment	Instruments	Equipment	Instruments	Chemicals
Carborundum Niagara Falls, N.Y.	Pangborn	x				
Ralph B. Carter Hackensack, N.J.				x		
Chemed Cincinnati, Ohio	Dearborn					x
Chicago Bridge & Iron Oak Brook, Ill.	Walker Process			x		
Clow Oak Brook, Ill.	Yeomans Bros.			x		
Combustion Engineering New York, N.Y.	Air Preheater; National Tank	x		x		
Combustion Equipment Associates New York, N.Y.		x	x			
Crane New York, N.Y.	Cochrane			x		
Culligan Northbrook, Ill.						x
Davis Water Thomasville, Ga.				x		
Dow Midland, Mich.						x
Dravo Pittsburgh, Pa.				x		
DuPont Wilmington, Del.		x	x	x		x
Ecodyne Chicago, Ill.	Graver; Fluor Products; Smith & Loveless			x		

Parent Company and Location	Divisions or Subsidiaries	Air		Water		
		Equipment	Instruments	Equipment	Instruments	Chemicals
Ecological Science Miami, Fla.			x	x	x	
Envirotech Salt Lake City, Utah	EIMCO; Buell; B-S-P; Sparling	x		x	x	
Foster Wheeler New York, N.Y.	Belco; Chemseps	x		x		
FMC San Jose, Calif.	Chicago Pump; Link Belt			x		
Fischer & Porter Warminster, Pa.				x	x	
Foxboro Foxboro, Mass.						x
General American Transportation Chicago, Ill.	Fuller	x				
General Signal New York, N.Y.	BIF Industries			x	x	
Hart-Carter Minneapolis, Minn.		x				
Hercules Wilmington, Del.						x
Honeywell So. Minneapolis, Minn.			x		x	
Joy Manufacturing Pittsburgh, Pa.	Western Precipitation; Denver Equipment	x		x		
Komline-Sanderson Peapack, N.J.				x		
Koppers Pittsburgh, Pa.		x		x		
Leeds & Northrup North Wales, Pa.			x		x	

Parent Company and Location	Divisions or Subsidiaries	Air		Water		
		Equipment	Instruments	Equipment	Instruments	Chemicals
Litton Beverly Hills, Calif.	Environmental Systems		x			
Marley Kansas City, Mo.				x		
Merck Rahway, N.J.	Calgon; Baltimore Aircoil			x	x	x
Midland-Ross Cleveland, Ohio		x				
Mogul Cleveland, Ohio						x
Monsanto St. Louis, Mo.	Enviro-Chem	x	x	x	x	x
Nalco Chicago, Ill.						x
Neptune Meter New York, N.Y.	Micro Floc; Nichols Engineering			x		
Olin Stamford, Conn.	Deady Chemical			x	x	x
Pall Corp. Glen Cove, N.Y.				x		
Peabody-Galion Galion, Ohio	Peabody Engineering Welles; Barnes	x		x		
Pennwalt Philadelphia, Pa.	Wallace & Tiernan; Sharples			x	x	
Research-Cottrell Bound Brook, N.J.	Hamon	x		x		
Rex Chainbelt Milwaukee, Wisc.	Pacific Flush Tank; American Water Softener			x		

Parent Company and Location	Divisions or Subsidiaries	Air		Water		
		Equipment	Instruments	Equipment	Instruments	Chemicals
Roberts Filter Darby, Pa.				x		
Singer New York, N.Y.				x		
Sly Mfg. (W.W.) Cleveland, Ohio		x				
Sterling Drug New York, N.Y.	Zimpro			x		
Sunbeam Chicago, Ill.	Illinois Water Treatment; John Zink	x		x		
Sybron Rochester, N.Y.	Permutit; Ionac; Taylor			x	x	x
Technicon Tarrytown, N.Y.			x		x	
Union Carbide New York, N.Y.	Linde		x	x	x	x
U.S. Filter Newport Beach, Calif.	Slick; Drew; Ducon	x				x
Universal Oil Products Des Plaines, Ill.	Air Correction	x				
Westinghouse Pittsburgh, Pa.	Infilco; Hagan Controls			x	x	
Westvaco New York, N.Y.						x
Wheelabrator-Frye Mishawaka, Ind.		x				
Zurn Industries Erie, Pa.	Fly Ash Arrestor; Sargent; Ludwig; Clarage	x		x		

SOURCE: Arthur D. Little, Inc.

TABLE A-2

A COMPARISON OF THE RETURN OF SALES FOR
POLLUTION CONTROL COMPANIES

APC Equipment - Particulate Control

1971 Earnings After Tax/Net Sales, (%)

	<u>Specific</u>	<u>General</u>
A. "IN" ¹ .		
American Air		
Filter	3.7	3.7
Envirotech	2.3	3.1
Buffalo Forge	-	5.7
Carborundum	-	4.0
Joy Mfg.	4.9	5.2
Peabody-Galion	2.4	3.9
Research-Cottrell	3.6	3.9
Wheelabrator-Frye	1.0	1.2
Zurn	(1.1)	1.6
Slick	3.6	3.6
B. "NEAR" ² .		
Combustion		
Engineering		3.4
General American Transportation		11.6
Koppers		3.1
Foster Wheeler		1.2

¹ U.O.P. and U.S. Filter not included.

² American Standard not included.

SOURCE: Securities and Exchange Commission Annual Reports
(Form 10-K) and Company Prospectuses.

TABLE A-3

A COMPARISON OF THE RETURN OF SALES FOR
POLLUTION CONTROL COMPANIES

APC Equipment - Gaseous Control

1971 Earnings After Tax/Net Sales, (%)

A. "NEAR" 1.

	<u>General</u>
Combustion Engineering	3.4
Midland-Ross	2.7
Monsanto	4.5
Peabody-Galion	3.9
Research-Cottrell	3.9
Sunbeam	4.0
Foster Wheeler	1.2
Babcock & Wilcox	2.1
Zurn	1.6

1. Boise Cascade and U.O.P. not included.

SOURCES: Securities and Exchange Commission Annual Reports
(Form 10-K) and Company Prospectuses.

TABLE A-4

A COMPARISON OF THE RETURN OF SALES FOR
POLLUTION CONTROL COMPANIES

WPC Equipment

1971 Earnings After Tax/Net Sales, (%)

		<u>Specific</u>	<u>General</u>
A. <u>"IN"</u>	Clow	-	4.1
	Dorr-Oliver	-	2.4
	Envirotech	3.6	3.1
	Marley	5.3	5.3
	Pennwalt	2.1	3.2
	Rex Chainbelt	4.0	3.4
	Ecodyne	3.1	3.1
B. <u>"NEAR"</u>	Chicago Bridge & Iron		8.3
	Merck		15.4
	Crane		1.4
	Dravo		1.3
	FMC		2.9
	Research-Cottrell		3.9
	Singer		3.3
	Sunbeam		4.0
	Sybron		4.9
	Westinghouse		3.8

SOURCE: Securities and Exchange Commission Annual Reports
(Form 10-K) and Company Prospectuses.

TABLE A-5

A COMPARISON OF THE RETURN OF SALES FOR
POLLUTION CONTROL COMPANIES

APC and WPC Instrumentation

1971 Earnings After Tax/Net Sales (%)

		<u>1971 Earnings After Tax/Net Sales (%)</u>	
		<u>Specific</u>	<u>General</u>
A. <u>"IN"</u>	Beckman	-	2.8
	Fischer & Porter (1972)	2.8	2.8
	Foxboro	-	4.3
	General Signal	5.4	4.8
	Leeds and Northrup	-	2.4
	Technicon	-	8.7
B. <u>"NEAR"</u>	Envirotech	3.6	3.1
	Sybron	5.1	4.9
	Honeywell	-	2.0
	Litton	-	2.0

SOURCES: Securities and Exchange Commission Annual
Reports (Form 10-K) and Company Prospectuses.

TABLE A-6

A COMPARISON OF THE RETURN OF SALES FOR
POLLUTION CONTROL COMPANIES

WPC Specialty Chemicals

1971 Earnings after tax/Net Sales (%)

		<u>Specific</u>	<u>General</u>
A. <u>"IN"</u>	Betz	7.4	7.4
	Chemed	10.0	10.0
	Mogul	-	5.5
	Nalco	9.4	9.4
	Calgon (1966)		
B. <u>"NEAR"</u>	Dow		7.5
	DuPont		9.3
	Hercules		6.6
	Merck		15.4
	Monsanto		4.5
	Olin		2.1
	Union Carbide		5.0
	Drew (Slick) ¹		2.3

¹ Before merger of Slick into U. S. Filter.

SOURCES: Securities and Exchange Commission Annual
Reports (Form 10-K) and Company Prospectuses.

TABLE A-7

FINANCIAL RATIOS OF SELECTED MANUFACTURERS OF AIR POLLUTION CONTROL

"IN"	EQUIPMENT - PARTICULATE CONTROL ¹							
	AAF	Envirotech	Buffalo Forge	Carborundum	Joy	Peabody Galion	Research Cottrell	Zurn Average
Net Income/ Net Sales (%)	1971 3.69 1970 3.76 1969 4.03	3.06 2.93 3.16	5.70 5.50 6.00	4.01 4.70 5.07	5.15 4.84 4.86	3.90 3.91 3.98	3.80 3.92 4.29	1.57 1.64 2.69 3.86 3.90 4.27
Net Income/ Total Assets (%)	1971 4.28 1970 4.79 1969 5.38	4.15 3.57 3.10	8.50 8.15 8.72	4.18 5.01 5.44	6.30 5.87 6.62	4.85 4.98 9.16	6.25 7.09 8.66	2.40 2.67 4.21 5.12 5.25 6.41
Debt/ Equity	1971 1.59 1970 1.26 1969 1.05	.824 1.42 1.33	.615 .763 .629	.699 .685 .698	.640 1.16 .521	.460 .745 .461	.596 .503 1.04	1.43 1.27 1.41 .856 .975 .892

¹ Universal Oil Products, and Wheelabrator-Frye not included.

SOURCES: Moody's Industrial Manual and Company
Annual Reports

TABLE A-8

FINANCIAL RATIOS OF SELECTED MANUFACTURERS OF AIR POLLUTION CONTROL EQUIPMENT

- PARTICULATE CONTROL ¹"NEAR"

		Comb. Eng.	Gatx	Koppers	Foster Wheeler	Average
Net Income/ Net Sales	1971 1970 1969	3.36 3.34 3.24	11.6 10.6 9.64	3.09 2.20 3.45	1.18 1.25 1.43	4.81 4.25 4.44
Net Income/ Total Assets	1971 1970 1969	4.96 5.07 4.73	4.51 4.29 4.12	4.29 2.67 4.78	2.75 2.31 3.02	4.13 3.74 4.16
Debt/ Equity	1971 1970 1969	1.53 1.40 1.36	1.59 1.56 1.50	.826 .942 .897	2.22 2.28 1.81	1.55 1.54 1.39

¹American Standard and Boise Cascade not includedSOURCES: Moody's Industrial Manual and Company
Annual Reports

TABLE A-9

FINANCIAL RATIOS OF SELECTED MANUFACTURERS OF AIR POLLUTION CONTROL EQUIPMENT
- GASEOUS CONTROL

"NEAR" (Only)		Comb. Eng.	Ionics	Midland Ross	Monsanto	Peabody Galion	Research Cottrell	Sunbeam	Foster Wheeler	Zurn	Babcock & Wilcox		Average
Met Income/ Net Sales	1971 1970 1969	3.36 3.34 3.24	1.74 1.59 4.28	2.69 1.16 1.78	4.5 4.0 5.6	3.90 3.91 3.98	3.90 3.92 4.29	4.0 3.5 3.5	1.18 1.25 1.43	1.57 1.64 2.69	2.16 1.21 .79	2.90 2.75 3.16	
Met Income/ Total Assets	1971 1970 1969	4.96 5.07 4.73	1.53 1.52 4.09	2.68 1.18 1.94	4.4 3.6 5.4	4.85 4.98 9.16	6.25 7.09 8.66	9.1 8.0 7.8	2.75 2.31 3.02	2.40 2.67 4.21	3.14 1.55 .96	4.21 3.80 5.00	
Debt/ Equity	1971 1970 1969	1.53 1.40 1.36	.428 .290 .330	.718 .736 .700	.76 .80 .67	.460 .745 .461	.596 .503 1.04	.84 .86 .81	2.22 2.28 1.81	1.43 1.27 1.41	1.25 1.32 1.14	1.02 1.02 .90	

I Boise Cascade, Combustion Equipment Associates, and Universal Oil Products not included

SOURCES: Moody's Industrial Manual and Company Annual Reports

TABLE A-10

FINANCIAL RATIOS OF SELECTED WATER POLLUTION CONTROL EQUIPMENT

MANUFACTURERS¹

			Clow	Envirotech	Marley	Pennwalt	Rex Chainbelt	Ecodyne	Average
Net Income/ Net Sales	"IN"	1971	4.15	3.06	5.32	3.19	3.39	3.12	3.71
		1970	0.65	2.93	5.14	3.00	3.79	3.31	3.14
		1969	5.47	3.16	2.42	4.20	4.38	2.37	3.67
Net Income/ Total Assets		1971	5.44	4.15	6.68	3.35	4.60	4.93	4.86
		1970	0.77	3.57	7.62	3.24	5.19	5.48	4.31
		1969	6.84	3.10	3.60	4.78	6.23	3.34	4.65
Total Debt/ Stockholders' Equity		1971	.342	.88	.499	.801	.879	NA	.680
		1970	.331	1.42	.950	.773	.837	NA	.862
		1969	.245	1.33	.957	.651	.592	NA	.755

¹ Bird & Sons, Dorr-Oliver, and Neptune Meter not included.

SOURCES: Moody's Industrial Manual and Company Annual Reports

TABLE A-11

FINANCIAL RATIOS OF SELECTED MANUFACTURERS OF WATER POLLUTION
CONTROL EQUIPMENT

		CB&I	Merck	Crane	Dravo	FMC	Research		Sunbeam	Sybron	Westing	
							Cottrell	Singer			House	Average
Net Income/ Net Sales	1971	8.34	15.4	1.41	1.33	2.87	3.90	3.3	4.0	4.92	3.78	4.92
	1970	4.42	15.1	1.22	2.51	4.42	3.92	3.6	3.5	3.82	2.94	4.55
	1969	2.81	14.9	2.11	2.61	4.78	4.29	3.9	3.5	5.50	4.27	5.17
Net Income/ Total Assets	1971	10.3	24.4	1.90	3.03	3.54	6.25	9.2	9.1	5.79	4.95	7.85
	1970	5.87	24.1	1.39	3.37	5.70	7.09	10.1	8.0	4.33	3.78	7.37
	1969	3.87	23.6	2.01	4.36	6.59	8.66	11.4	7.8	6.20	6.05	8.05
Total Debt/ Stockholders' Equity	1971	1.29	.36	2.68	1.32	.740	.506	1.16	.84	0.99	.991	10.9
	1970	.88	.35	2.85	1.47	.670	.503	1.12	.86	1.11	1.26	11.1
	1969	.75	.34	2.80	1.04	.733	1.04	1.21	.81	1.03	.784	10.5

SOURCES: Moody's Industrial Manual and Company Annual Reports

TABLE A-12

**FINANCIAL RATIOS OF SELECTED MANUFACTURERS OF INSTRUMENTATION FOR AIR
AND WATER POLLUTION CONTROL¹**

<u>"IN"</u>		<u>Beckman</u>	<u>Fischer & Porter</u>	<u>Foxboro</u>	<u>Leads & Northrup</u>	<u>Technicon</u>	<u>General Signal</u>	<u>Average</u>
Net Income/ Net Sales	1971 1970 1969	2.84 3.57 3.27	2.74 .436 (1.23)	4.26 3.79 3.68	2.38 3.48 3.56	8.7 12.2 15.9	4.86 4.55 5.00	4.29 4.09 5.03
Net Income/ Total Assets	1971 1970 1969	2.98 3.67 3.53	3.34 .453 (1.21)	4.34 3.93 3.65	3.52 4.98 3.65	7.04 11.9 13.9	7.30 6.75 7.92	4.75 5.28 5.24
Debt/ Equity	1971 1970 1969	.812 .940 .880	1.45 1.88 1.83	.449 .564 .407	.584 .739 1.23	.548 .462 .508	.466 .516 .481	.718 .851 .889

¹ Neptune Meter not included

SOURCES: Moody's Industrial Manual and Company Annual Reports

TABLE A-13

**FINANCIAL RATIOS OF SELECTED MANUFACTURERS OF INSTRUMENTATION FOR AIR
AND WATER POLLUTION CONTROL**

" NEAR "

		<u>Envirotech</u>	<u>Honeywell</u>	<u>Litton</u>	<u>Sybron</u>	<u>Average</u>
Net Income/	1971	3.06	3.56	7.02	4.92	3.39
Net Sales	1970	2.93	3.21	2.86	3.82	3.21
	1969	3.16	3.38	3.78	5.50	3.96
Net Income/	1970	4.15	3.17	2.53	5.79	4.09
Total Assets	1970	3.57	3.06	3.56	4.33	3.98
	1969	3.10	3.56	5.21	6.20	6.03
Total Debt/	1971	.824	1.86	1.43	.987	1.18
Stockholders' Equity	1970	1.42	2.43	1.51	1.11	1.45
	1969	1.33	2.58	1.24	1.03	1.33

SOURCES: Moody's Industrial Manual and Company Annual Reports

TABLE A-14

FINANCIAL RATIOS FOR SELECTED MANUFACTURERS OF SPECIALTY
CHEMICALS FOR WATER POLLUTION CONTROL¹

<u>"IN"</u>		<u>Betz</u>	<u>Nalco</u>	<u>Mogul</u>	<u>Average</u>
Net Income/ Net Sales	1971	7.41	9.5	5.54	7.48
	1970	6.93	7.9	5.41	6.75
	1969	7.42	9.4	4.58	7.13
Net Income/ Total Assets	1971	11.7	14.1	8.41	11.4
	1970	13.4	13.9	8.48	11.9
	1969	15.1	15.5	7.87	12.8
Total Debt/ Stockholders Equity		.189	.291	.355	.278
		.459	.320	.746	.508
		.346	.377	.543	.422

¹ Chemed not included.

SOURCES: Moody's Industrial Manual and Company Annual Reports.

TABLE A-15

FINANCIAL RATIOS FOR SELECTED MANUFACTURERS OF SPECIALTY
CHEMICALS FOR WATER POLLUTION CONTROL¹

<u>"NEAR"</u>		<u>Dow</u>	<u>DuPont</u>	<u>Hercules</u>	<u>Merck</u>	<u>Monsanto</u>	<u>Olin</u>	<u>Union Carbide</u>	<u>Average</u>
Net Income/	1971	7.5	9.3	6.6	15.4	4.5	2.1	5.0	7.18
Net Sales	1970	6.8	9.2	6.5	15.1	4.0	2.4	5.2	6.89
	1969	8.3	9.8	5.9	14.9	5.6	4.3	6.3	7.87
Net Income/	1971	5.0	8.9	6.8	17.9	4.4	2.1	4.3	7.06
Total Assets	1970	4.6	8.9	6.3	17.8	3.6	2.4	4.4	6.86
	1969	5.7	10.3	5.6	17.6	5.4	4.6	5.5	7.81
Total Debt/	1971	1.57	.29	.71	.36	.76	.98	.93	.801
Stockholders'	1970	1.49	.26	.95	.35	.80	.88	.97	.823
Equity	1969	1.43	.29	1.00	.34	.67	.76	.90	.771

¹ Westvaco not included

SOURCE: Moody's Industrial Manual and Company Annual Reports.

TABLE A-16

CALCULATION OF FIXED AND VARIABLE COSTS

	APC Particulate Control Equipment		APC Gaseous Control Equipment		WPC Equipment		Instrumentation		WPC Specialty Chemicals	
	SIC 3540	Σ	SIC 3440	Σ	SIC 3580	Σ	SIC 3810	Σ	SIC 2898	Σ
Net Sales	1,574,616	97.95	1,633,304	97.14	1,446,156	96.19	1,648,703	97.70	1,821,305	97.09
Other Income	32,993	2.86	48,106	2.86	57,678	3.84	38,733	2.30	54,559	2.91
Total Receipts	1,607,609	100	1,681,410	100	1,503,834	100	1,687,436	100	1,875,864	100
Total Deductions	1,467,904	91.31	1,601,664	95.26	1,419,167	94.37	1,600,088	94.82	1,722,408	91.82
Cost of Sales & Operation	1,004,743	62.50	1,207,896	71.84	1,078,200	71.70	1,078,582	63.91	1,090,805	58.15
Other Fixed Costs	226,145	14.07	180,508	10.74	163,318	10.86	229,147	13.58	258,427	13.78
Other Variable Costs	227,992	14.18	194,061	11.54	160,617	10.68	268,352	15.90	340,384	18.15
Interest	19,878	1.24	16,200	0.96	19,032	1.27	21,898	1.30	32,642	1.74
Total Receipts Less Costs	139,705	8.69	79,746	4.74	84,667	5.63	87,348	5.18	153,456	8.18
Foreign Dividends	1,791	0.11	8,923	0.53	190	.01	2,644	0.16	8,085	.43
Operating Profit	141,493	8.80	88,224	5.25	84,717	5.63	89,869	5.33	161,201	8.59
Income After Tax	74,031	4.61	48,777	2.90	45,589	3.03	51,584	3.06	93,256	4.97
CGS		62.50		71.84		71.70		63.91		58.15
Fixed-Other Labor		9.73		7.46		8.57		18.83		8.68
Variable-Materials		37.50		47.26		50.28		29.36		43.38
Production Labor		15.27		17.11		12.85		15.72		6.09
Summary: ..		23.80		18.20		19.43		32.41		22.46
Fixed Costs		66.95		75.91		73.81		60.98		67.52
Variable Costs		1.24		0.96		1.27		1.30		1.74
Σ of Total Receipts		8.80		4.74		5.63		5.33		8.59

SOURCES: 1968-1969 IRS Corporation Income Tax Returns, 1967 Census of Manufacturers

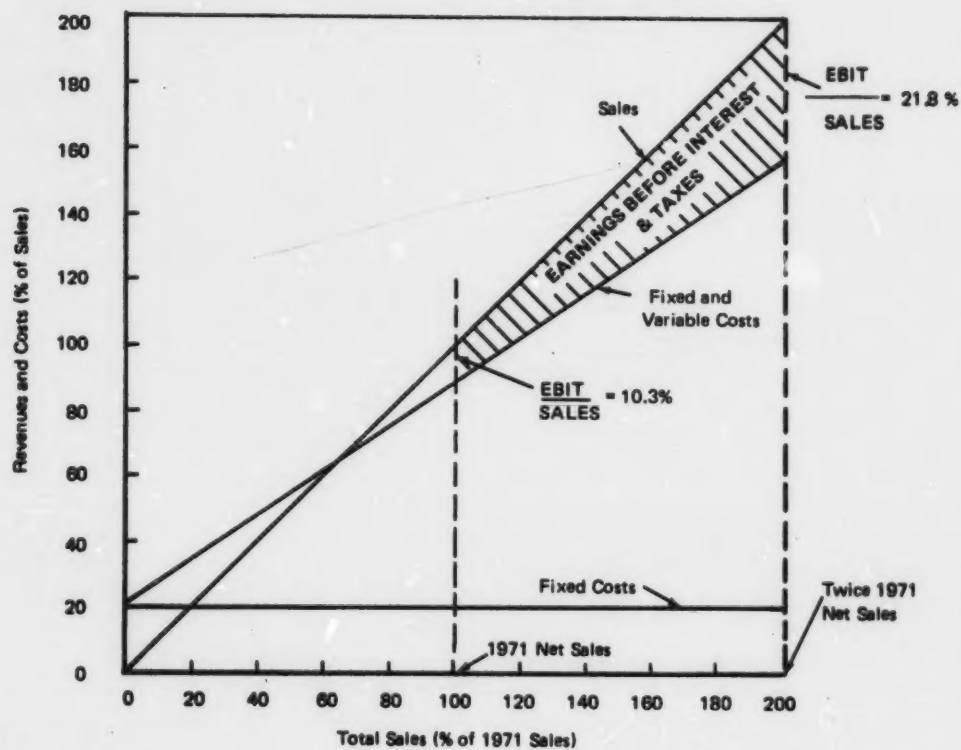


FIGURE A-1 EFFECT OF VARYING SALES ON EARNINGS BEFORE INTEREST AND TAXES: SPECIALTY CHEMICALS

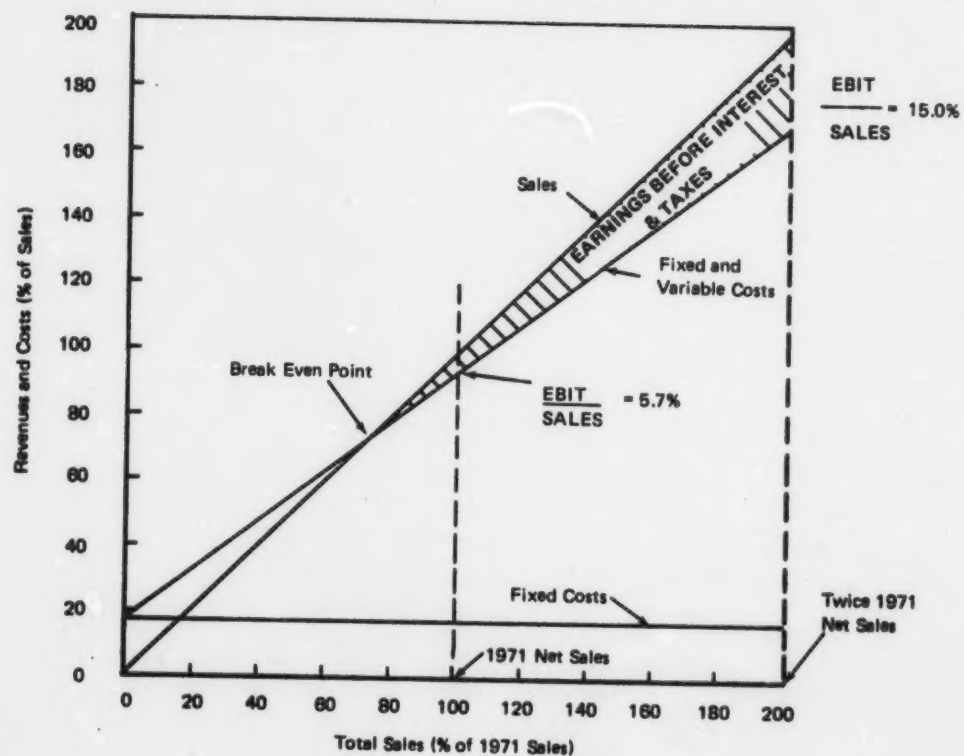


FIGURE A-2 EFFECT OF VARYING SALES ON EARNINGS BEFORE INTEREST AND TAXES: APC EQUIPMENT - GASEOUS CONTROL

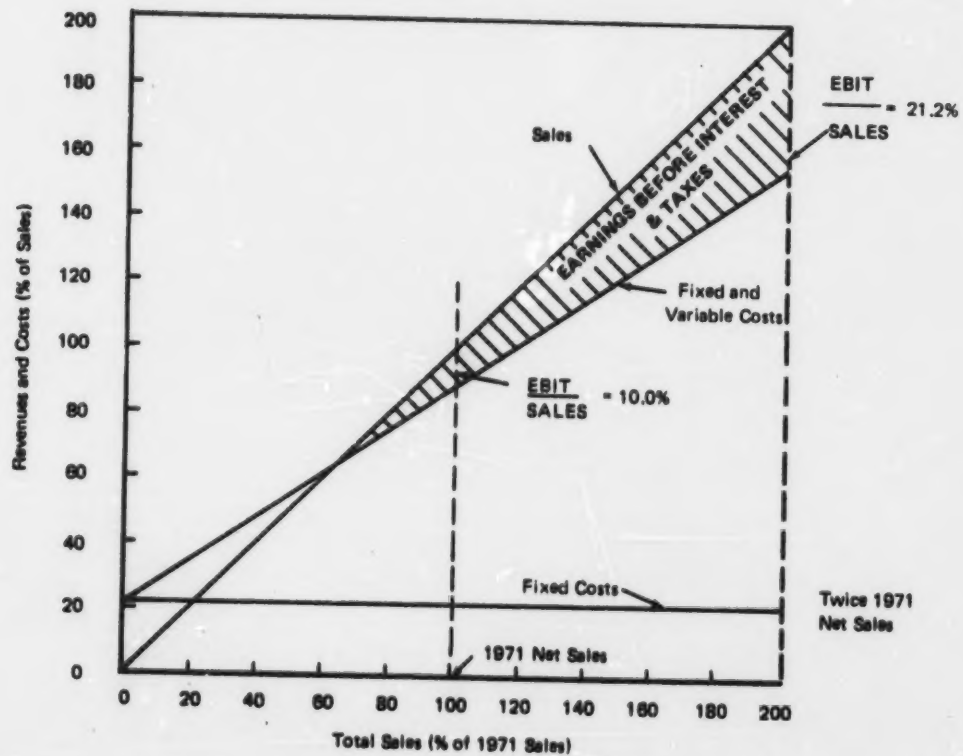


FIGURE A-3 EFFECT OF VARYING SALES ON EARNINGS BEFORE INTEREST AND TAXES: APC EQUIPMENT - PARTICULATE CONTROL

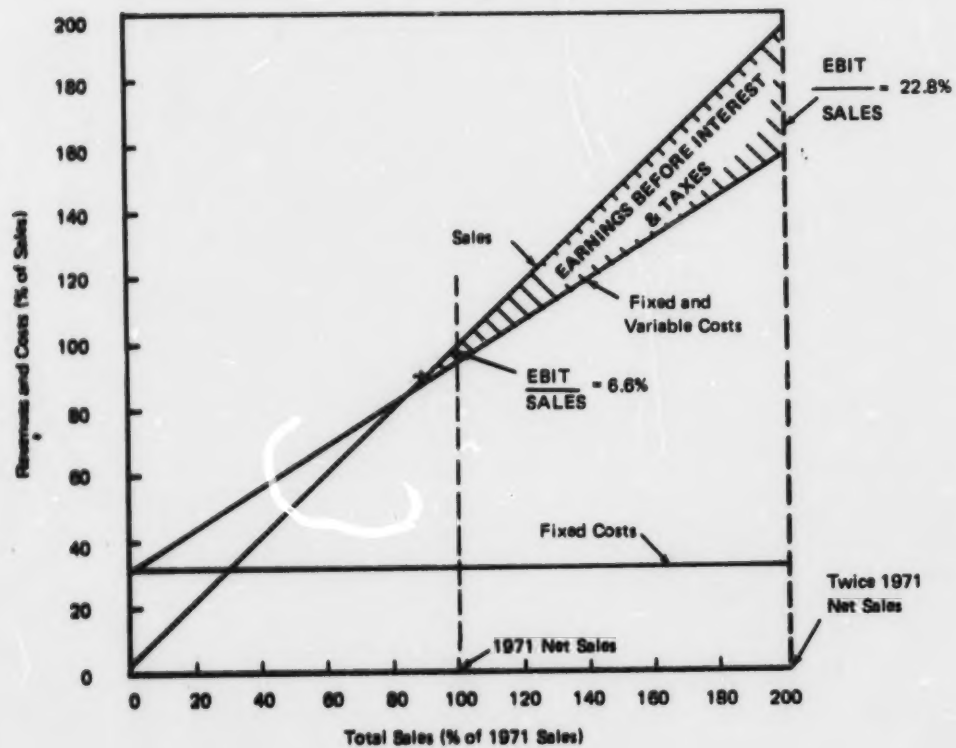


FIGURE A-4 EFFECT OF VARYING SALES ON EARNINGS BEFORE INTEREST AND TAXES: INSTRUMENTATION

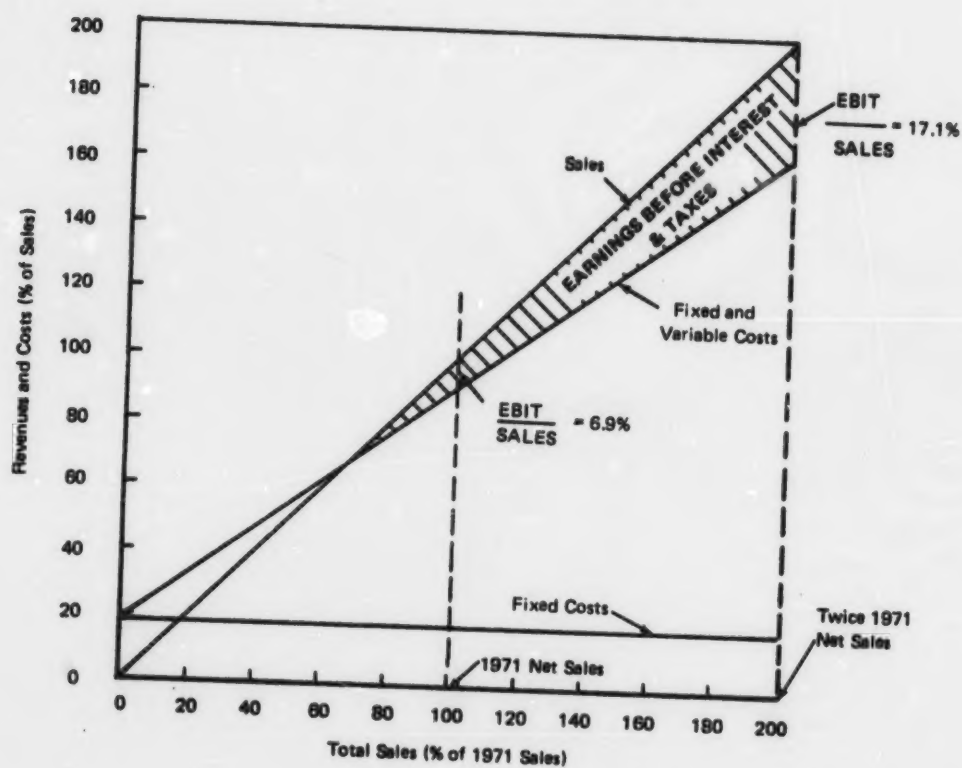


FIGURE A-5 EFFECT OF VARYING SALES ON EARNINGS BEFORE INTEREST AND TAXES: WPC EQUIPMENT

APPENDIX B – FOR CHAPTER II

TABLE B-1

DESCRIPTION OF MAJOR POLLUTION ABATEMENT EQUIPMENT

a. AIR POLLUTION CONTROL

Electrostatic Precipitator.-A device which separates aerosol particulate matter (solid or liquid) from industrial gases by imparting an electric charge to the particles and removing them from the gas stream with the force created by an electric field. It is utilized to clean gases with concentrations of particulate matter of one-tenth of a grain per cubic foot of gas and over.

Fabric Filter.-A device in which the dust bearing gas is passed through a fabric in such a manner that the dust particles are retained on the up stream or "dirty" gas side of the fabric, while the cleaned gas passes through the fabric to the down stream or clean gas side, whence it is removed by natural and/or mechanical means. The fabric may be of any fibrous material whether natural or man-made.

Mechanical Collector.-A device for the separation in a dry state of entrained particulate material from a gas stream by the application of a combination of the following forces: centrifugal, inertial, gravitational.

Scrubber, Particulate.-A device for the removal of particulate contaminants from a gas stream by means of intimate contact with the scrubbing liquid.

Scrubber, Gaseous.- A device for the removal of soluble or reactive gaseous material from gas streams by contacting the stream with water, aqueous chemical solutions, or other scrubbing.

TABLE B-1 (cont'd) DESCRIPTION OF MAJOR POLLUTION ABATEMENT EQUIPMENT

Incinerator.-A device for the removal of combustible air contaminants or oxident streams wherein the air contaminant is:

- preheated by a suitable heating mechanism and then passed through a catalyst bed which initiates and promotes oxidation of the combustible contaminants to carbon dioxide, water vapor, and other compounds less noxious than those originally in the gas stream (catalytic incinerator).

- passed over a burner or other suitable preheat device to a thermal residence chamber where the contaminant materials are converted to carbon dioxide, water vapor, and other materials less noxious than originally in the gas stream (normal incinerator).

- reacted directly with a fuel or with oxidizing air in a burner flame and the products of combustion exhausted to the atmosphere directly or through a suitable incineration chamber and stack (flame incinerator).

Gas Adsorber.-A device for the removal of air contaminants by adsorption on a surface-active solid such as activated carbon or molecular sieves. Non-regenerable systems accumulate air contaminant materials in the adsorbent until it is exhausted, at which time the adsorbent is discarded. Regenerable systems periodically provide for the removal of the adsorbed contaminant materials in such a manner as to prevent air pollution.

TABLE B-1 (cont'd) DESCRIPTION OF MAJOR POLLUTION ABATEMENT EQUIPMENT

b. SEWAGE AND WASTEWATER TREATMENT EQUIPMENT SPECIALTY EQUIPMENT

Aerators.-Equipment which delivers oxygen to water by the introduction of air.

- this is accomplished by cascades, air diffusers, blowers, nozzles, surface and submerged mechanical equipment, compressors and auxiliaries.

Chemical feeders.-Either by dry feed or solution feed accurately prepared and measure the chemicals required for the treatment process. Dry feeders measure chemicals volumetrically or gravimetrically. Solution feeders dose the liquid with measured solution of chemicals.

Chlorinators.-Gas or solution chlorinators accurately prepare, measure and inject the chlorine gas or solution needed for the disinfection treatment process.

Degritters.-Gravity-type grit collectors and cyclone grit separators (centrifugal force) are used to remove inert material from the sewage flow which will not be affected by the treatment process, but which would adversely affect the maintenance or operation costs of the system if not removed. Also include grit washers, aerated grit chambers with appurtenances.

Dewatering.-Further concentration of sludge removal from the solids portion. This is principally performed by vacuum filters and centrifuges with associated accessories.

Wet combustion, sludge incineration.-The process whereby the organic content of sludge is partially reduced by the application of medium to high temperatures and super atmospheric pressure to prepare the sludge for further dewatering and/or disposal.

TABLE B-1 (cont'd) DESCRIPTION OF MAJOR POLLUTION ABATEMENT EQUIPMENT

Digestion.--Tanks in which anaerobic action on sewage sludge stabilizes the organic matter so that it can be handled with minimum odor and health hazard. Includes steel covers, gas holders, propeller or gaslift mixers, sludge heaters, sludge heat exchangers, gas utilization and control equipment.

Filter underdrains, (including filters).--Serve to collect liquid evenly from the gravity flow filter bed or to distribute evenly the reverse flow wash water for the washing of the filter beds. Generally they are pipe grids, vitrified clay blocks, carborundum plates, or false bottoms with porcelain balls in pyramidal openings or strainers, or precast concrete blocks or plates with special diffuser nozzles.

Ion exchange (and demineralization).--The principles of removing or replacing the mineral content in water; demineralization is applied to the removal of all minerals, while ion exchange removes hardness. In both processes water is brought in contact or filtered through natural or synthetic chemicals to accomplish the removal or exchange.

Mixers.--Imparts to the fluid the proper agitation to blend the chemicals evenly with the raw liquid flow and is accomplished by specially designed basins (baffles) or by mechanical means (pumps or flash agitators).

TABLE B-1 (cont'd) DESCRIPTION OF MAJOR POLLUTION ABATEMENT EQUIPMENT

Pressurized flotation.-Equipment for round or rectangular basins incorporating bottom sludge removal, surface skimming, pressurizing pumps, air compressor and specialized metering chemical feeding, pressure regulating accessories.

Pumps.-Used exclusively in the treatment process to lift all or any portion of the flow, to add chemicals, pump sludge and to operate and maintain the treatment plant or process.

Screens and disintegrators.-Grating, perforated plates or parallel bars and grinders and comminutors are used respectively to remove or reduce in size those foreign bodies which appear in the flow, so as to prevent hydraulic problems in the system.

Sedimentation.-Permits quiescent settling to remove those floc particles or other foreign particles which are undesirable in the liquid being treated. This is accomplished in a horizontal flow tank in which settled material is scraped from the bottom. Flocculation and particles which are undesirable in the liquid flow tanks as the fluid rises and is either retained by a sludge covering which has formed or settles out. Aeration, grit removal, flotation and sludge thickening can also be combined with sedimentation in a single unit. This category also includes gravity-type sludge thickening equipment.

Package pumping stations.-Prefabricated units in which the pump and accessories are housed ready for installation.

c. INSTRUMENTATION

Filter gauges.-Instruments which record the operations of a filter by indicating the rate of flow, loss of head through filters and depth of water in the clear water basin.

TABLE B-1 (cont'd) DESCRIPTION OF MAJOR POLLUTION ABATEMENT EQUIPMENT

Filter rate controllers.-Measure or control the flow of water through a plant or portion of a plant by means of Venturi tubes, flow nozzles, orifice plates or weirs. Control consoles serve as an automated, control point to operate, measure and record filter performance.

Meters and controls.-Used to operate treatment plants by remote and automatic control. Does not include metering of service connections.

Water Quality Monitoring.-Equipment that provides measurements of the parameters determining the quality of stream, lake or plant effluent water.

TABLE B-2
AIR POLLUTION CONTROL
INDUSTRIAL PROCESSES
REQUIRED CAPITAL INVESTMENT, 1972-1980^a
(Millions of 1972 Dollars)

<u>Industrial Sector^b</u>	<u>Predominant Control Hardware</u>	<u>Control Costs^c</u>
Asphalt Batching	Mechanical collectors with venturi scrubbers (small plants) or fabric filters (large plants)	368
Coal Cleaning	Venturi scrubbers	27
Cement	Fabric filters (dry kilns) or electrostatic precipitators (wet kilns)	105
Ferroalloy	Fabric filters and electrostatic precipitators	330
Grain: Handling	Low efficiency cyclone collectors with fabric filters	469
Milling	Fabric filters	26
Iron Foundries	Afterburners (cupola) with scrubbers or fabric filters	426
Iron-Steel	Electrostatic precipitators, fabric filters, or wet scrubbers	977
Kraft (sulfate) Pulp	Mechanical collectors and scrubbers	170
Lime	Mechanical collectors with scrubbers (small kilns) or fabric filters (large kilns)	38
Natural Gas Production	Scrubbers	52
Nitric Acid	Catalytic reduction	44
Petroleum Refining	Oxidation and electrostatic precipitators	385
Phosphate Fertilizer	Venturi scrubbers	38
Preliminary Non-Ferrous:		
Aluminum	Dry or wet scrubbers; dry or wet electrostatic precipitators	1079
Copper	Scrubbers	374
Lead	Scrubbers	40
Zinc	Scrubbers	33
Secondary Non-Ferrous:	Fabric filters and scrubbers	39
Sulfuric Acid	Absorption with scrubbers (old plants); dual absorption (new plants)	206
Other ^d	-----	740
	TOTAL	5966

^aIncludes all equipment and services for start-up; omits annual operating costs.

^bIncludes only those sectors for which data on cost, emission, and growth factors was made available; we estimate above listed industries to account for 85% of potential equipment markets.

^cIncludes investment costs required to meet present federal legislation on all existing non-controlled facilities and new facilities over the period 1972-1980.

^dIncludes crushed stone, sand and gravel, clay products, forest products, lime crushing, and carbon black among others.

SOURCE: Environmental Protection Agency; Arthur D. Little, Inc. estimates.

TABLE B-3
STEAM-ELECTRIC POWER GENERATION
REQUIRED CAPITAL INVESTMENT, 1972-1980

	<u>Number of Plants</u>	<u>Power Capacity (10³ MW)</u>
Coal Fired Installations, 1972:	960	195
Plant Attrition, 1972-1975:	- 280	- 5
Retirement, if > 100 MW		
Fuel Substitution, if < 100 MW		
	-----	-----
Coal Fired Installations, 1975:	680	190
Fuel Substitution, Low-Sulfur Coal:	- 170	- 50
Accelerated Retirements, Fuel Switching, Coal Cleaning:	- 50	- 15
	-----	-----
Remaining Plants, 1975:	450	125
SO ₂ Control Cost, \$50/kwh		
Plants in Place, 1975:		\$5000 million
Annual Growth, 6%/Year:		
1976:	300	
1977:	320	
1978:	340	
1979:	370	
1980:	400	

		\$6730 million

SOURCE: Federal Power Commission; Environmental Protection Agency,
 Arthur D. Little, Inc. estimates.

TABLE B-4
SOLID WASTE INCINERATION
REQUIRED CAPITAL INVESTMENT, 1972-1980

	<u>1968</u>	<u>1970</u>	<u>1972</u>	<u>1975</u>	<u>1980</u>
Municipal Collected Waste (Lbs./day/person)	4.3	4.5	5.0	5.5	6.3
Total Collected Refuse ^a (10 ⁶ tons/year)	80	90	100	115	145
Shipments to Incinerators (10 ⁶ tons/year)	19.6	20.4	22.5	26.0	32.0
Active Incinerator Capacity (Tons/day)	90	100	110	128	158

	<u>Date of Incinerator Installation</u>			
	<u>Pre-1968</u>	<u>1968-72</u>	<u>1973-75</u>	<u>1976-80</u>
Required Investment (\$/ton/day)	570	545	640	680
Operating Cost (\$/ton)	0.77	0.75	0.81	0.92
Capital Investment: (Millions of 1972 dollars)	51.3	10.9	11.5	20.5
Total Investment:				94.2
Operating Cost/Year: (Millions of 1972 Dollars)	61.6	15.0	12.2	27.6

SOURCE: Arthur D. Little, Inc. estimates.

TABLE B-5

MUNICIPAL SEWAGE TREATMENT

CONSTRUCTION PUT-IN-PLACE, 1958-71

<u>Year</u>	<u>Millions of Current Dollars</u>	<u>STP Deflator (1957-59=100)</u>	<u>Millions of Constant Dollars</u>	<u>Growth (%/Year)</u>
1958	706	101.5	696	7.6% ↑
1959	772	103.7	744	
1960	836	105.0	796	
1961	790	105.8	747	
1962	939	107.0	878	
1963	1146	108.5	1056	
1964	1485	110.1	1349	
1965	1306	112.0	1166	0.6% ↑
1966	1432	116.1	1233	
1967	1177	119.4	986	
1968	1697	123.6	1373	
1969	1491	132.7	1124	
1970	1647	143.6	1146	
1971	2065	162.1	1271	

SOURCE: Department of Commerce; Environmental Protection Agency

TABLE B-6

**MUNICIPAL SEWAGE TREATMENT PLANTS
REQUIRED CAPITAL INVESTMENT, 1972-80^a**
(Millions of 1972 Dollars)

<u>Item</u>	<u>New Facility</u>	<u>Modification^b</u>	<u>Increase In Capacity</u>	<u>Increase In Treatment Level</u>	<u>Increase In Capacity And Treatment Level</u>	<u>TOTAL</u>
Treatment Plant Proper:						
Primary	151.6	48.6	350.0	1.4	12.6	564.2
Intermediate ^c	6.7	3.2	31.7	73.4	20.4	135.4
Secondary ^d	2039.6	371.5	929.6	1313.7	1803.7	6458.1
Tertiary	955.7	15.2	186.7	868.0	1114.4	3140.0
Phosphate Removal	166.1	2.2	3.4	15.7	20.8	208.2
Nitrate Removal	213.4	—	—	8.7	26.3	248.4
Disinfection	18.1	48.7	1.7	7.2	3.8	79.5
Sludge Processing	497.6	118.4	43.4	3.5	89.6	752.5
Sludge Disposal	254.0	51.8	49.8	31.7	—	387.3
TOTAL	4302.8	659.6	1596.3	2323.3	3091.6	11973.6
Ancillary Facilities^e						
Sanitary Interceptors Sewer	4570.9	26.8	271.8	—	11.0	4880.5
Combined Interceptors Sewer	257.9	20.5	31.9	—	—	310.3
Pumping Stations	509.2	13.8	76.7	—	27.9	627.6
Outfall	1362.7	14.6	49.3	—	38.6	1465.2
Deep Ocean Outfall	180.3	0.4	25.1	—	—	205.8
TOTAL	6881.0	76.1	454.8	—	77.5	7489.4
GRAND TOTAL	11183.8	735.7	2051.1	2323.3	3169.1	19463.0

^aBased on December 1971 EPA survey of municipalities serving populations of 10,000 or more.

^bNo increase in either capacity or treatment.

^cApproximately 80% BOD removal.

^dApproximately 85% BOD removal.

^eItems often included within wastewater treatment plants as defined by EPA; excludes trunk sewers, overflow control projects, and force mains.

SOURCE: Environmental Protection Agency; Arthur D. Little, Inc. estimates.

TABLE B-7

MUNICIPAL SEWAGE TREATMENT

CASE I: BASELINE GROWTH INDEX, 1965-80

Year	U.S. Domestic Population		Per Capita Municipal Withdrawal		Population Served by Municipal Wastewater Systems		Combined Multiplier Index
	Millions	Growth (%/year)	Gal./capita/day	Growth (%/year)	Percent of Population	Growth (%/year)	
1955	165.1		146 ^a		59.5		
1960	180.0	1.7	161	2.0	61.6	0.7	-
1965	194.5	1.6	178 ^a	2.0	64.9	1.0	-
1970	204.8	1.0	190 ^a	1.5	69.0 ^a	1.3 ^c	1.038
1975	216.6	1.1	205 ^a	1.5	75.0 ^a	1.6	1.043
1980	232.9	1.5	217	1.5	82.0	1.9	1.050

SOURCES: Bureau of the Census,^b
Department of Commerce

The Outlook for Water,
Resources for the Future, Inc.

Business and Defense Services
Administration,
Department of Commerce

^a Arthur D. Little, Inc. estimates

^b Bureau of the Census, Current Population Reports, P25, Series I-C, March 1972.

^c In agreement with growth over same period as reported by FWPCA, The Economics of Clean Water, March 1970.

TABLE B-8

CASE I: BASELINE

MUNICIPAL SEWAGE TREATMENT
ESTIMATED EQUIPMENT SHIPMENTS, 1972-80

	Annual Shipments (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Specialty Equipment												
Aerators	8.9	9.3	9.6	10.1	10.5	11.1	11.6	12.2	12.8	13.5		
Chemical Feeders	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6		
Chlorinators	6.1	6.4	6.6	7.0	7.2	7.6	8.0	8.4	8.8	9.2		
Degritters	1.7	1.8	1.9	2.0	2.0	2.1	2.2	2.4	2.5	2.6		
Devatering.	6.8	7.1	7.3	7.7	8.0	8.4	8.8	9.3	9.7	10.2		
Digestion	9.9	10.3	10.7	11.2	11.8	12.2	12.9	13.5	14.1	14.9		
Filter Underdrains	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8		
Ion Exchange Units	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2		
Mixers	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3		
Pressurized Flotation	1.8	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.9		
Pumps	15.7	16.6	17.2	18.1	18.8	19.7	20.6	21.7	22.8	24.0		
Screens, Disintegrators	4.5	4.7	4.9	5.1	5.3	5.6	5.9	6.2	6.5	6.9		
Sedimentation	11.2	11.6	12.1	12.7	13.2	13.8	14.6	15.3	16.0	16.8		
Package Pumping Stations	10.5	10.9	11.2	11.8	12.4	12.9	13.6	14.3	14.9	15.7		
Package Treatment Plants	18.4	19.3	19.9	21.0	21.8	22.9	24.1	25.3	26.5	27.9		
TOTAL	96.7	101.3	104.9	110.3	114.8	120.3	126.5	132.9	139.2	146.5		
Instrumentation												
Filter Rate Control, Filter												
Gauges	1.0	1.0	1.0	1.1	1.2	1.2	1.3	1.3	1.4	1.5		
Meters and Controls	8.9	9.3	9.6	10.1	10.5	11.0	11.6	12.2	12.8	13.4		
Water Quality Monitoring	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6		
TOTAL	10.3	10.7	11.1	11.7	12.2	12.7	13.5	14.1	14.8	15.5		
GRAND TOTAL	107	112	116	122	127	133	140	147	154	162	4.3	5.0

SOURCE: Arthur D. Little, Inc. estimates.

TABLE B-9
CASE II: FEDERAL COMPLIANCE SCHEDULE
MUNICIPAL SEWAGE TREATMENT
ESTIMATED EQUIPMENT SHIPMENTS, 1972-80

	Annual Shipments (Millions of 1972 Dollars)										Growth (Z/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Specialty Equipment												
Aerators	15.4	18.4	23.2	32.4	42.7	53.1	43.1	29.7	16.4	10.5	29.1	-24.5
Chemical Feeders	2.8	3.8	5.1	7.5	10.5	14.9	12.2	9.5	4.3	2.7	39.2	-23.8
Chlorinators	3.5	4.3	5.1	6.7	8.8	11.0	9.2	6.6	3.5	2.2	25.9	-24.2
Degritters	1.2	1.4	1.9	2.6	3.2	3.2	2.3	1.1	1.0	0.7	27.8	-26.3
Dewatering,	18.1	21.5	27.9	39.7	54.3	74.7	62.0	46.8	22.1	14.2	31.7	-23.6
Digestion	2.7	3.2	4.7	7.4	9.5	11.0	8.3	4.9	3.3	2.1	37.0	-26.0
Filter Underdrains	1.8	2.2	2.9	3.9	5.4	8.1	6.7	5.5	2.3	1.5	31.7	-22.7
Ion Exchange Units	0.6	0.9	1.4	2.4	3.6	5.9	4.9	4.1	1.6	1.0	63.4	-22.7
Mixers	1.8	2.3	3.3	5.0	7.0	10.4	8.5	6.9	2.9	1.9	40.4	-23.0
Pressurized Flotation	2.5	3.0	3.7	5.3	7.1	10.2	8.6	6.8	3.1	1.9	29.8	-23.2
Pumps	20.3	22.8	28.8	40.2	52.8	65.1	52.8	36.0	20.3	12.9	27.0	-24.6
Screens & Disintegrators	5.7	6.6	8.4	11.6	15.6	20.0	16.5	11.8	6.2	3.9	28.7	-24.2
Sedimentation	11.0	10.8	13.0	17.2	22.3	26.0	21.2	13.9	8.4	5.4	19.3	-24.7
Package Pumping Stations	10.4	10.8	13.0	17.2	22.3	26.0	21.2	13.9	8.4	5.4	21.0	-24.7
Package Treatment Plants	12.5	13.6	16.2	21.4	26.8	28.6	22.8	13.2	9.6	6.2	21.0	-23.4
TOTAL	109.9	125.6	158.6	220.5	291.9	368.2	300.3	210.7	113.4	72.5	27.6	-24.4
Instrumentation												
Filter Rate Control, Filter												
Gauges	1.8	2.2	2.9	3.9	5.2	8.3	6.7	5.5	2.3	1.5	30.3	-22.0
Meters and Controls	13.1	16.1	20.5	28.5	39.1	54.3	45.5	35.0	16.1	10.4	31.4	-23.3
Water Quality Monitoring	2.2	3.1	4.1	6.3	9.3	15.3	13.1	11.2	4.2	2.7	43.3	-21.9
TOTAL	17.1	21.4	27.5	38.7	53.6	77.9	65.3	51.7	22.6	14.6	33.0	-23.0
GRAND TOTAL	127.0	147.0	186.1	259.2	345.5	446.1	365.6	262.4	136.0	87.1	28.4	-24.1

SOURCE: Arthur D. Little, Inc. estimates.

TABLE B-10

MUNICIPAL SEWAGE TREATMENT EQUIPMENTEQUIPMENT MIX, 1970-80

(Percent of Annual Shipments)

	<u>1970</u>	<u>1972</u>	<u>1975</u>	<u>1980</u>
Specialty Equipment				
Aerators	11.7	12.5	12.5	11.5
Chemical Feeders	1.9	2.5	3.0	3.5
Chlorinators	2.5	3.0	2.5	2.5
Degritters	0.9	1.0	1.0	0.5
Dewatering,	13.8	14.5	15.5	17.5
Digestion	2.3	2.0	3.0	2.0
Filter Underdrains	1.3	1.5	1.5	2.0
Ion Exchange Units	0.4	0.5	1.0	1.5
Mixers	1.3	1.5	2.0	2.5
Pressurized Flotation	1.9	2.0	2.0	2.5
Pumps	16.4	15.5	15.5	14.0
Screens, Disintegrators	4.4	4.5	4.5	4.5
Sedimentation	9.9	7.5	6.5	5.5
Package Pumping Stations	8.8	7.5	6.5	5.5
Package Treatment Plants	<u>10.1</u>	<u>9.5</u>	<u>8.0</u>	<u>5.5</u>
TOTAL	87.6	85.5	85.0	81.0
Instrumentation				
Filter Rate Control, Filter				
Gauges	1.4	1.5	1.5	2.0
Meters and Controls	9.6	11.0	11.0	13.0
Water Quality Monitoring	<u>1.4</u>	<u>2.0</u>	<u>2.5</u>	<u>4.0</u>
TOTAL	12.4	14.5	15.0	19.0
GRAND TOTAL	100.0	100.0	100.0	100.0

SOURCE: Department of Commerce; Arthur D. Little, Inc. estimates.

TABLE B-11
CASE III: EXPECTED COMPLIANCE SCHEDULE

MUNICIPAL SEWAGE TREATMENT

ESTIMATED EQUIPMENT SHIPMENTS, 1972-80

	Annual Shipments (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Specialty Equipment												
Aerators	15.4	16.6	18.0	22.2	27.4	32.5	34.7	36.8	39.7	41.6	15.5	8.7
Chemical Feeders	2.8	3.3	3.8	5.0	6.6	8.2	9.2	10.2	11.5	12.7	24.0	14.0
Chlorinators	3.5	4.0	4.1	4.7	5.5	6.6	7.2	7.7	8.5	9.1	12.0	10.6
Degritters	1.2	1.3	1.4	1.8	2.2	2.4	2.3	2.2	2.0	1.8	16.4	-3.9
Dewatering,	18.1	19.2	21.3	27.0	33.9	42.0	46.8	51.6	58.1	63.3	16.2	13.3
Digestion	2.7	2.7	3.4	4.7	6.6	7.4	7.5	7.4	7.5	7.2	25.0	1.8
Filter Underdrains	1.8	2.0	2.2	2.7	3.3	4.2	4.9	5.6	6.4	7.2	16.4	16.9
Ion Exchange Units	0.6	0.7	1.0	1.5	2.2	2.9	3.4	4.0	4.7	5.4	38.1	19.7
Mixers	1.8	2.0	2.4	3.3	4.4	5.5	6.3	7.1	8.1	9.1	25.0	15.6
Pressurized Flotation	2.5	2.7	2.9	3.6	4.4	5.5	6.3	7.1	8.1	9.1	15.2	13.6
Pumps	20.3	20.6	22.3	27.6	33.9	40.2	42.8	45.1	48.5	50.7	13.7	8.4
Screens & Disintegrators	5.7	6.0	6.5	8.0	9.8	11.9	12.9	13.9	15.3	16.3	14.5	10.7
Sedimentation	11.0	10.0	10.3	12.2	14.2	16.6	17.5	18.2	19.3	19.9	6.6	7.0
Package Pumping Stations	10.4	10.0	10.3	12.2	14.2	16.6	17.5	18.2	19.3	19.9	8.1	7.0
Package Treatment Plants	12.5	12.6	13.0	15.1	17.5	19.8	20.1	20.1	20.3	19.9	8.8	2.6
TOTAL	109.9	113.7	122.9	151.6	186.1	222.3	239.4	255.2	277.3	293.2	14.1	9.5
Instrumentation												
Filter Rate Control, Filter												
Gauges	1.8	2.0	2.2	2.7	3.3	4.2	4.9	5.6	6.4	7.2	16.4	16.9
Meters and Controls	13.1	14.6	15.8	19.6	24.1	30.1	33.8	37.7	42.7	47.1	16.5	14.5
Water Quality Monitoring	2.2	2.7	3.1	4.1	5.5	7.4	8.9	10.5	12.6	14.5	25.7	29.5
TOTAL	17.1	19.3	21.1	26.4	32.9	41.7	47.6	53.8	61.7	68.8	17.9	15.9
GRAND TOTAL	127	133	144	178	219	264	287	309	339	362	14.6	10.6

SOURCE: Arthur D. Little, Inc. estimates.

TABLE B-12
MUNICIPAL SEWAGE TREATMENT
REQUIRED EQUIPMENT SHIPMENTS, 1972-80

	<u>Cumulative Shipments, 1972-80</u> <u>(Millions of 1972 Dollars)</u>	<u>Distribution</u> <u>(Percent)</u>
Specialty Equipment		
Aerators	269.5	12.0
Chemical Feeders	70.5	3.2
Chlorinators	57.4	2.3
Degritters	17.4	0.8
Dewatering,	363.2	16.2
Digestion	54.4	2.4
Filter Underdrains	38.5	1.7
Ion Exchange Units	25.8	1.2
Mixers	48.2	2.5
Pressurized Flotation	49.7	2.2
Pumps	331.7	14.8
Screens, Disintegrators	100.6	4.5
Sedimentation	138.2	6.2
Package Pumping Stations	138.2	6.2
Package Treatment Plants	158.4	7.1
TOTAL	1861.7	83.3
Instrumentation		
Filter Rate Control, Filter Gauges	38.5	1.7
Meters and Controls	265.5	11.9
Water Quality Monitoring	69.3	3.1
TOTAL	373.3	16.7
GRAND TOTAL	2235.0	100.0

SOURCE: Arthur D. Little, Inc. estimates.

TABLE B-13
INDUSTRIAL WASTEWATER TREATMENT
REQUIRED CAPITAL INVESTMENT, 1948-1980^a

SIC	INDUSTRY	REQUIRED INVESTMENT (Millions of 1967 Dollars)			
		WATER PRODUCTIVITY, GROWTH FACTOR ^b	PLANTS IN PLACE, 1948	INDUSTRY GROWTH, 1948-1980	TOTAL
201	Meat Products	1.026	104.7	35.5	140.2
202	Dairy Products	1.044	65.0	41.3	106.3
203	Canned, Frozen Preserved Foods	1.026	212.7	72.2	284.9
2041-3	Flour & Other Grain Mill Products	1.065	16.9	17.7	34.6
2046	Wet Corn Milling	1.040	16.6	9.0	25.6
205	Bakery Products	0.975	15.3	--	15.3
2061-2	Cane Sugar	1.028	182.8	76.5	259.2
2063	Soot Sugar	0.991	85.2	--	85.2
207	Confectionary & Related Products	0.993	12.5	--	12.5
208	Beverages	1.019	99.4	23.9	123.3
209	Misc. Foods & Kindred Products	1.004	102.1	4.9	107.0
20XX	Other Food Processing	1.026	1.0	40.5	41.5
221	Weaving Mills, Synthetic	1.070	14.7	17.4	32.1
223	Weaving & Finishing Mills, Wool	1.006	47.0	3.2	50.2
22XX	Other Textiles	1.068	172.0	229.0	401.0
24	Lumber & Wood Products	0.981	116.1	--	116.1
261	Pulp Mills	1.000	552.4	--	552.4
2621	Paper Mills, Exc. Bldg. Paper	1.009	401.1	429.4	830.5
263	Paper Board Mills	1.047	229.1	138.1	367.2
264	Misc. Connec. Paper Products	1.045	17.0	11.3	28.3
265	Paperboard Cont. & Boxes	1.046	14.8	10.0	24.8
266	Building Papers	0.935	23.5	--	23.5
2812	Alkalies & Chlorine	0.960	6.3	--	6.3
2813	Industrial Gases	1.026	10.9	3.2	14.1
2815	Cyclic Crudes & Intermediates	1.001	5.8	.2	6.0
2816	Inorganic Pigments	1.026	4.7	1.4	6.1
2818	Industrial Organic Chemicals	1.045	630.2	371.2	1001.4
2819	Industrial Inorganic Chemicals	1.037	36.8	29.5	66.3
283	Pharmaceuticals	1.003	11.0	.2	11.2
284	Toiletries & Detergents	1.007	1.2	.2	1.4
2851	Paints	0.984	4.1	--	4.1
286	Wood Chemicals	0.943	2.9	--	2.9
287	Agricultural Chemicals	1.028	12.2	4.2	16.4
289	Misc. Chemical Products	1.242	25.4	246.4	271.8
2911	Petroleum Refining	1.008	2440.4 ^d	300.3 ^e	2640.7
29XX	Petroleum & Coal - Other Than Refining	1.009	23.5 ^f	59.5 ^g	83.0
30	Rubber & Plastics	1.049	82.5	58.1	140.6
311	Leather Tanning & Finishing	1.024	80.0	26.2	106.2
31XX	Leather	1.032	6.8	12.9	19.7
321-3	Glass	0.998	28.9	--	28.9
324	Cement	1.002	26.8	.6	27.4
325-6	Clay	1.000	5.1	--	5.1
327	Concrete & Plaster	1.046	42.9	27.7	70.6
328	Stone	1.032	4.3	2.2	6.5
329	Non-Metallic Minerals	1.025	48.9	15.3	64.2
3312	Blast Furnaces & Steel Mills	1.035	839.4	342.4	1181.8
3321	Gray Iron Foundries	1.017	11.2	2.3	13.5
3331	Primary Copper	1.024	16.6	4.5	21.1
3332	Primary Lead	1.065	2.0	2.1	4.1
3333	Primary Zinc	1.065	3.9	4.2	8.1
3334	Primary Aluminum	1.014	98.7	16.8	115.5
33XX	Other Primary Metals	1.035	423.1	291.2	714.3
34	Fabricated Metals	1.050	100.1	76.2	176.3
35	Machinery	1.008	80.6	7.8	88.4
36	Electric Machinery	1.033	112.7	46.6	159.3
37	Trans. Equipment	1.018	79.2	16.2	95.4
TOTALS			7811.2	3049.6	11860.8
ADJUSTED TOTAL (est. 1972 dollars) ^h			10935.7	4269.4	15205.1

^a Total investment only, omits operating and maintenance costs, replacement and cost of capital.

^b Based on production growth and change in annual water intake, 1959-1968.

^c Includes investment required for incineration: \$193.3 million.

^d Includes investment required for activated sludge treatment process: \$1632.0 million.

^e Includes investment required for activated sludge treatment process: \$134.0 million.

^f Includes investment required for activated sludge treatment process: \$14.0 million.

^g Includes investment required for activated sludge treatment process: \$35.3 million.

^h Based on Sewage Treatment Plant Construction Cost Index given in 1972 Economics of Clean Water, Vol. I, pg. 62.

SOURCE: Arthur D. Little, Inc. estimates, based on 1972 Economics of Clean Water, EPA.

TABLE B-14
INDUSTRIAL PLANT INVESTMENT, 1963-1980

<u>Year</u>	<u>Industrial Plant Investment (Millions of 1958 Dollars)</u>	<u>Annual Growth (Percent)</u>	<u>Long Term Growth (Percent)</u>
1963	34.0	--	
1964	38.7	13.8	
1965	44.0	13.7	
1966	50.1	13.9	
1967	50.6	1.0	
1968	52.7	4.2	7.6
1969	56.9	8.0	
1970	54.0	- 5.1	
1971	56.9 ^c	5.4	
1972	61.0		
1973	64.3		
1974	67.8		
1975	71.3		
1976	75.2		5.4
1977	79.2		
1978	83.5		
1979	88.0		
1980	91.6		

^aMore specifically, Fixed Investment, Producers' Durable Equipment, Gross Private Domestic Investment, as reported in the National Income and Product Accounts.

^bEstimates over the period 1972 to 1980 are based upon Arthur D. Little's macroeconomic model of the national economy.

^cPreliminary estimate, DOC.

SOURCE: Office of Business Economics, Department of Commerce; Arthur D. Little, Inc. estimates.

TABLE B-15

CASE I: BASELINE

INDUSTRIAL WASTEWATER TREATMENT

ESTIMATED EQUIPMENT SHIPMENTS, 1972-80

	Annual Shipments (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Specialty Equipment												
Aerators	10.1	10.7	11.2	11.8	12.4	13.1	13.9	14.6	15.5	16.4		
Chemical Feeders	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.1	1.1		
Chlorinators	3.7	3.9	4.1	4.3	4.5	4.8	5.0	5.3	5.6	5.9		
Degritters	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.6		
Dewatering, Wet Combustion	4.3	4.5	4.8	5.1	5.3	5.6	5.9	6.2	6.6	6.9		
Digestion	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.5		
Filter Underdrains	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9		
Ion Exchange Units	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9		
Mixers	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5		
Pressurized Flotation	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2		
Pumps	17.3	18.3	19.3	20.3	21.3	22.6	23.8	25.1	26.6	28.1		
Screens, Disintegrators	4.3	4.5	4.8	5.0	5.3	5.6	5.9	6.2	6.6	6.9		
Sedimentation	6.2	6.6	6.9	7.3	7.7	8.1	8.5	9.0	9.5	10.1		
Package Pumping Stations	1.2	1.2	1.5	1.4	1.4	1.5	1.6	1.7	1.8	1.9		
Package Treatment Plants	3.2	3.4	3.6	3.8	4.0	4.2	4.5	4.7	5.0	5.3		
TOTAL	56.2	59.4	62.8	66.0	69.2	73.3	77.3	81.4	86.4	91.2		
Instrumentation												
Filter Rate Control, Filter												
Gauges	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9		
Meters and Controls	10.9	11.5	12.1	12.8	13.4	14.2	15.0	15.8	16.7	17.7		
Water Quality Monitoring	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2		
TOTAL	12.8	13.6	14.2	15.0	15.8	16.7	17.7	18.6	19.6	20.8		
GRAND TOTAL	69	73	77	81	85	90	95	100	106	112	5.4	5.4

S. REE: Arthur D. Little, Inc. estimates.

TABLE B-16

CASE II: FEDERAL COMPLIANCE SCHEDULE

INDUSTRIAL WASTEWATER TREATMENT

ESTIMATED EQUIPMENT SHIPMENTS, 1972-80

	Annual Shipments (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Specialty Equipment												
Aerators	22.7	24.4	25.4	27.1	27.9	28.7	17.1	9.4	8.7	6.9	5.3	-24.4
Chemical Feeders	4.4	5.6	6.9	8.1	8.7	9.6	6.2	3.7	2.7	3.2	18.6	-18.1
Chlorinators	5.0	5.4	5.5	5.6	5.8	6.0	3.6	2.1	1.8	0.3	3.8	-22.7
Degritters	1.9	2.2	1.7	1.6	1.6	1.5	0.9	0.6	0.5	0.3	-4.2	-28.5
Dewatering, Wet Combustion	28.2	32.3	37.4	40.7	44.3	47.3	29.9	17.5	14.2	13.6	12.0	-21.0
Digestion	4.7	5.6	6.1	6.7	7.0	7.4	4.5	2.5	2.2	1.9	10.5	-23.0
Filter Underdrains	2.8	3.3	3.7	3.9	4.2	4.4	2.7	1.5	1.2	1.2	10.7	-17.8
Ion Exchange Units	0.9	1.1	1.2	1.3	1.6	1.9	1.3	0.9	0.8	0.6	15.5	-21.0
Mixers	3.6	4.5	5.9	6.4	7.5	8.5	5.8	3.7	3.2	2.3	20.1	-22.4
Pressurized Flotation	3.9	4.5	4.9	5.3	5.7	5.8	3.6	2.0	1.7	1.6	10.0	-23.3
Pumps	31.4	33.4	35.3	37.7	39.4	40.9	24.8	13.9	12.3	10.5	5.8	-23.0
Screens, Disintegrators	6.9	9.0	9.0	9.5	10.0	10.3	6.4	3.6	3.2	2.7	9.7	-24.3
Sedimentation	17.4	17.8	21.3	23.5	24.6	25.1	15.1	8.3	7.4	6.1	8.1	-27.7
Package Pumping Stations	16.7	17.8	20.6	22.3	22.8	22.5	13.0	6.9	6.6	4.5	7.6	-23.6
Package Treatment Plants	21.1	24.5	26.2	28.1	28.3	28.2	16.3	8.7	8.4	5.6	8.7	-23.2
TOTAL	171.6	191.4	211.1	227.8	239.4	248.1	151.2	85.3	74.9	62.6	8.7	-23.6
Instrumentation												
Filter Rate Control, Filter												
Gauges	2.8	3.3	3.7	3.9	4.2	4.4	2.7	1.5	1.2	1.2	10.7	-22.2
Mixers and Controls	19.6	22.3	24.5	26.6	28.5	29.8	18.8	10.9	8.8	8.7	9.8	-21.2
Water Quality Monitoring	4.0	5.6	6.9	7.8	8.9	9.9	6.6	4.1	3.7	2.7	22.1	-21.3
TOTAL	26.4	31.2	35.1	38.3	41.6	44.1	28.1	16.5	13.7	12.6	12.0	-21.3
GRAND TOTAL	198.0	222.6	246.2	266.1	281.0	292.2	179.3	101.8	88.6	75.2	9.1	-23.2

SOURCE: Arthur D. Little, Inc. estimates.

TABLE B-17
INDUSTRIAL WASTEWATER TREATMENT
EQUIPMENT MIX, 1970-80
(Percent of Annual Shipments)

	<u>1970</u>	<u>1972</u>	<u>1975</u>	<u>1980</u>
Specialty Equipment				
Aerators	11.9	11.0	10.0	9.0
Chemical Feeders	1.9	2.5	3.0	4.0
Chlorinators	2.6	2.5	2.0	2.0
Degritters	0.9	1.0	0.5	0.5
Dewatering, Sludge Incineration	14.0	14.5	15.5	18.0
Digestion	2.3	2.5	2.5	2.5
Filter Underdrains	1.3	1.5	1.5	1.5
Ion Exchange Units	0.4	0.5	0.5	1.0
Mixers	1.6	2.0	2.5	4.0
Pressurized Flotation	1.9	2.0	2.0	2.0
Pumps	16.7	15.0	14.0	13.5
Screens, Disintegrators	3.0	4.0	3.5	3.5
Sedimentation	9.6	8.0	9.0	8.0
Package Pumping Stations	8.9	8.0	8.5	6.0
Package Treatment Plants	<u>10.3</u>	<u>11.0</u>	<u>10.5</u>	<u>7.5</u>
TOTAL	87.4	86.0	85.5	83.0
Instrumentation				
Filter Rate Control, Filter				
Gauges	1.3	1.5	1.5	1.5
Meters and Controls	9.8	10.0	10.0	11.0
Water Quality Monitoring	<u>1.5</u>	<u>2.5</u>	<u>3.0</u>	<u>4.5</u>
TOTAL	12.6	14.0	14.5	17.0
GRAND TOTAL	100.0	100.0	100.0	100.0

SOURCE: Department of Commerce, Arthur D. Little, Inc. estimates.

TABLE B-18
CASE III: EXPECTED COMPLIANCE SCHEDULE

INDUSTRIAL WASTEWATER TREATMENT

ESTIMATED EQUIPMENT SHIPMENTS, 1972-80

	Annual Shipments (Millions of 1972 Dollars)										Growth (Z/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
Specialty Equipment												
Aerators	22.7	23.4	24.4	24.9	24.9	25.0	22.5	13.8	8.8	7.9	2.3	-20.5
Chemical Feeders	4.4	5.4	6.1	6.8	7.8	8.2	8.0	5.3	3.6	3.5	15.4	-14.8
Chlorinators	5.0	5.4	5.4	5.2	5.0	5.0	4.7	2.9	1.9	1.8	0	-18.5
Degritters	1.9	2.1	1.9	1.6	1.2	1.2	1.2	0.7	0.5	0.4	-10.8	-19.7
Dewatering, Wet Combustion	28.2	31.0	34.0	36.6	38.4	40.8	38.7	25.0	16.8	15.8	8.0	-16.3
Digestion	4.7	5.4	5.7	6.0	6.2	6.4	5.9	3.7	2.4	2.2	7.2	-18.7
Filter Underdrains	2.8	3.2	3.4	3.6	3.7	3.8	3.5	2.2	1.4	1.3	7.2	-18.8
Ion Exchange Units	0.9	1.1	1.1	1.2	1.2	1.7	1.6	1.2	0.9	0.9	7.5	-5.6
Mixers	3.6	4.3	5.0	5.8	6.2	7.1	7.3	5.0	3.6	3.5	14.6	-10.8
Pressurized Flotation	3.9	4.3	4.6	4.8	5.0	5.1	4.7	2.9	1.9	1.8	6.4	-18.5
Pumps	31.4	32.1	33.6	34.5	34.9	35.4	32.4	20.2	13.2	11.9	2.7	-19.4
Screeners, Disintegrators	6.9	8.6	8.8	8.8	8.9	8.7	8.2	5.2	3.4	3.1	6.6	-19.0
Sedimentation	17.4	17.1	19.1	20.9	22.4	22.5	20.1	12.3	7.8	7.0	6.5	-20.6
Package Pumping Stations	16.7	17.1	18.7	20.2	21.0	20.7	17.6	10.3	6.2	5.3	5.9	-24.1
Package Treatment Plants	21.1	23.5	24.8	25.7	26.1	25.2	21.8	12.8	7.8	6.6	5.5	-24.1
TOTAL	171.6	184.0	196.6	206.6	212.9	216.8	198.2	123.5	80.2	73.0	5.5	-19.3
Instrumentation												
Filter Rate Control, Filter												
Gauges	2.8	3.2	3.4	3.6	3.7	3.8	3.5	2.2	1.4	1.3	7.2	-18.9
Meters and Controls	19.6	21.4	22.9	24.0	24.9	26.0	24.0	15.6	10.4	9.7	6.2	-17.2
Water Quality Monitoring	4.0	5.4	6.1	6.8	7.5	8.4	8.3	5.7	4.0	4.0	17.0	-11.8
TOTAL	26.4	30.0	32.4	34.4	36.1	38.2	35.8	23.5	15.8	15.0	8.1	-16.1
GRAND TOTAL	198	214	229	241	249	255	234	147	96	88	5.9	-18.8

SOURCE: Arthur D. Little, Inc. estimates.

TABLE B-19
INDUSTRIAL WASTEWATER TREATMENT
REQUIRED EQUIPMENT SHIPMENTS, 1972-80

	<u>Cumulative Shipments, 1972-80</u> <u>(Millions of 1972 Dollars)</u>	<u>Distribution</u> <u>(Percent)</u>
Specialty Equipment		
Aerators	175.6	10.0
Chemical Feeders	54.7	3.1
Chlorinators	37.4	2.1
Degritters	10.9	0.6
Dewatering, Wet Combustion	277.2	15.8
Digestion	43.9	2.5
Filter Underdrains	26.1	1.5
Ion Exchange Units	10.7	0.6
Mixers	47.8	2.7
Pressurized Flotation	35.1	2.0
Pumps	248.2	14.2
Screens, Disintegrators	63.7	3.7
Sedimentation	149.2	8.5
Package Pumping Stations	137.0	7.8
Package Treatment Plants	<u>174.3</u>	<u>10.0</u>
TOTAL	1491.8	85.1
Instrumentation		
Filter Rate Control, Filter Gauges	26.1	1.5
Meters and Controls	178.9	10.2
Water Quality Monitoring	<u>56.2</u>	<u>3.2</u>
TOTAL	261.2	14.9
GRAND TOTAL	1753.0	100.0

SOURCE: Arthur D. Little, Inc. estimates.

TABLE B-20
MUNICIPAL SEWAGE TREATMENT RELATIVE USAGE OF INDIVIDUAL PRODUCT TYPES^a

Product Type	Primary	Intermediate	Secondary	Tertiary ^b	Phosphate Removal	Nitrate Removal	Disinfection	Sludge Processing	Sludge Disposal	Estimated Cumulative Equipment Disposition 1972-80 ^c
Specialty Equipment										
Aerators	xxx	xxx	xxx	xxx				xx		249.5
Chemical Feeders			xx	xxx	xxx	xx		xxx		70.5
Chlorinators							xxx	x	x	57.4
Degritters	xxx									17.4
Dewatering, Wet Combustion	xxx	xxx	xxx	xxx				xxx		363.2
Digestion	xxx	xxx	xxx	xx				xxx		54.4
Filter Underdrains			x	xx		xx		xxx		38.5
Ion Exchange Units						xx				25.8
Mixers	xx	xx	xxx	xxx	xxx	xxx	xx	xxx	xx	48.2
Pressurized Flotation			xxx	xxx		xx				49.7
Pumps	xxx	xxx	xxx	xxx	xxx	xxx	xx	xxx	xx	331.7
Screens, Disintegrators	xxx	xx								100.6
Sedimentation	xxx	xxx	xxx	xxx	xx					138.2
Package Pumping Stations	xxx	xxx	x	x						138.2
Package Treatment Plants		xxx	xx	x						158.4
										1,861.7
Instrumentation										
Filter Base Control, Filter Gages			x	xx		xx				38.5
Meters and Controls	xx	xx	xxx	xxx	xxx	xxx		xxx		265.5
Water Quality Monitoring		xx	xxx	xxx	xxx	xx	xx			59.3
Approximate Capital Investment Required, 1972-1980: C, d	565	135	6,460	3,140	210	250	80	750	390	373.3

^axxx--high usage; xx--moderate usage; x--low usage.

^bIncludes membrane processes.

^cIncludes treatment plant proper only.

SOURCE: Arthur D. Little, Inc., estimates.

TABLE B-21
INDUSTRIAL WASTEWATER TREATMENT RELATIVE USAGE OF INDIVIDUAL PRODUCT TYPES^a

Product Type Specialty Equipment	TYPE OF PROCESS													Estimated Cumulative Equipment Shipments, 1972-80 ^b
	Oil Sep- ARATION	Equali- zation	Coagulation & Flocculation	Neutral- ization	Flota- tion	Sedimen- tation	Aer- ation	Biological Stabilizer	Chlori- nation	Evapor- ation	Incin- eration	Activated Sludge	Denitrifi- cation	
Aerators			XXX		XXX			XXX				XXX		175.6
Chemical Feeders				XXX	XXX									54.7
Chlorinators									XXX					37.4
Degritters					XXX							XXX		10.9
Desulfuring, Wet Combustion			XX		XXX						XXX	XXX		277.2
Digestion								XXX				XXX		43.9
Filter Underdrains			XX	XXX										26.1
Ion Exchange Units												X		10.7
Mixers	XXX	XXX		XXX			XXX	XXX					XX	47.8
Pressurized Flotation	XXX											XX		35.1
Pumps	XXX			XX	XXX									248.2
Screens, Disintegrators		XX			XX					XX	XX	XXX		63.7
Sedimentation									XXX					149.2
Package Pumping Stations					XXX							XXX		137.0
Package Treatment Plants												XXX		174.3
Instrumentation														1,491.8
Filter Rate Control			XX										X	26.1
Meters and Controls				XX	XXX							XXX		178.9
Water Quality Monitoring	XXX											XXX		56.2
Approximate Capital Investment Required, 1972-1980: ^b	1,800	290	1,320	950	30	1,390	100	1,140	10	150	150			261.2

^a xxx--high usage; xx--moderate usage; x--low usage.

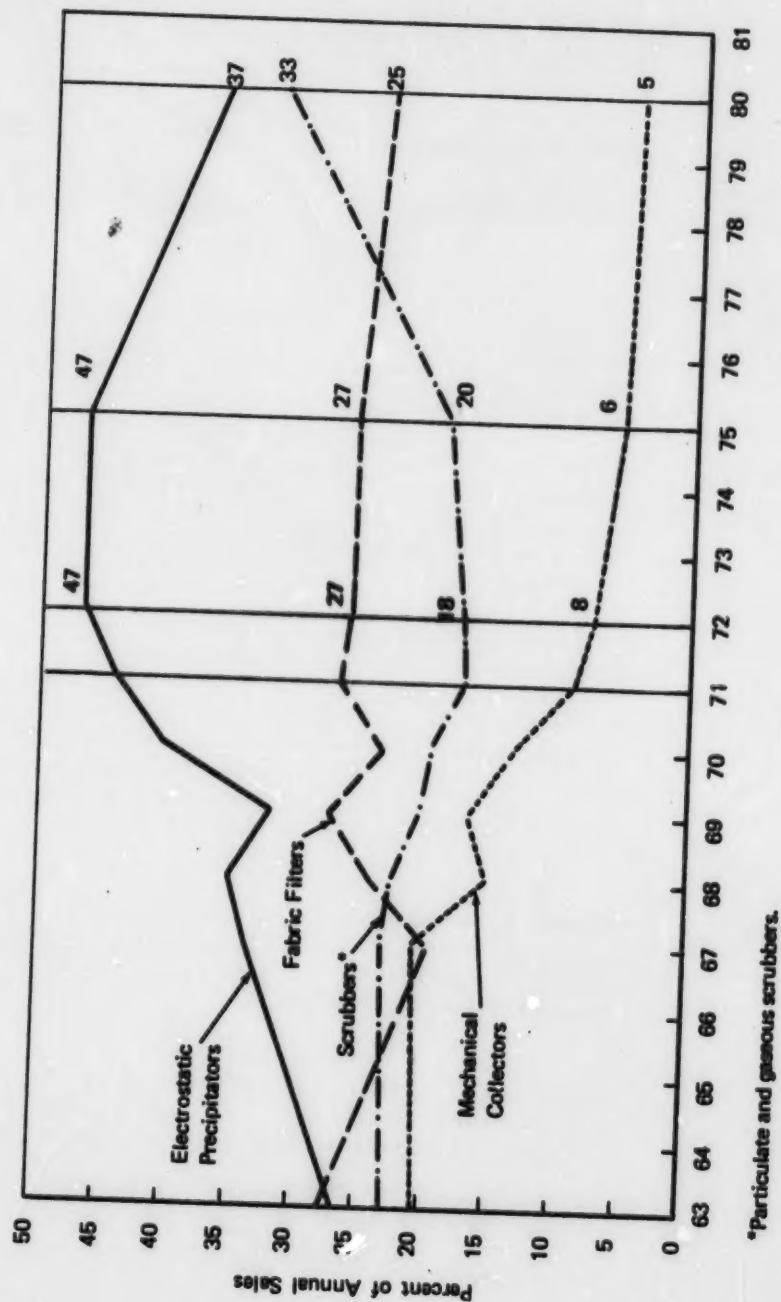
^bMillions of 1972 dollars.

SOURCE: Arthur D. Little, Inc., estimates.

TABLE B-22
WATER POLLUTION ABATEMENT
CRITICAL PRODUCT TYPES

	<u>Municipal Sewage</u>	<u>Industrial Wastewater</u>
Estimated Cumulative Equipment Shipments, 1972-80:	\$2,235,000,000	\$1,753,000,000
High Importance:	Aerators Digestion Dewatering Meters and Controls Mixers Pumps Sedimentation Wet Combustion Water Quality Monitoring	Chemical Feeders Dewatering Meters and Controls Mixers Pumps Sedimentation Water Quality Monitoring
Moderate Importance:	Chemical Feeders Chlorination Package Treatment Plants Pressurized Flotation	Aerators Degritters Filter Rate Control, Filter Gauges Filter Underdrains Ion Exchange Units Pressurized Flotation Wet Combustion
Low Importance:	Filter Rate Control, Filter Gauges Filter Underdrains Package Pumping Stations	Chlorinators Digestion
Not Critical:	Degritters Ion Exchange Units Screens, Disintegrators	Package Pumping Stations Package Treatment Stations Screens, Disintegrators

SOURCE: Arthur D. Little, Inc.



Source: Industrial Gas Cleaning Institute, Department of Commerce; Arthur D. Little, Inc. estimates.

FIGURE B-1 AIR POLLUTION CONTROL
ESTIMATED EQUIPMENT MIX, 1972-80

APPENDIX C - FOR CHAPTER III

EXHIBIT C: Questionnaire Survey of Pollution Abatement Companies

FIRM _____ YEAR _____

- 1) Total Wages, Salaries, and Benefits as a Percent of Total Net Sales Revenue¹ _____

Also as a percent of Net Sales Revenue, the wages, salaries, and benefits of the following groups:

- a) Administration or management _____
b) Sales and technical service _____
c) Project or design engineering _____
d) R & D and laboratory staff _____
e) Draftsmen _____
f) Production, maintenance, operation _____

- 2) Total Materials Expenses as a Percent of Total Net Sales Revenue _____

Also as a percent of Net Sales Revenue:

- a) Manufactured or fabricated input costs _____
b) Raw material resource costs _____

- 3) Other Expenses² as a Percent of Total Net Sales Revenue _____

Total as a Percent of Total Net Sales Revenue 100%

¹Total Net Sales Revenue is total revenue excluding such non-sales revenue as interest income.

²Other Expenses should include net interest paid, depreciation, taxes, and net income. In other words, it is the residual revenues left after defraying the labor and materials bills.

EXHIBIT C (CONT'D)

Elasticity Information

The following page is geared to assessing how elastic or how "easily available" the different factors of production actually are. The questionnaire asks, for example, by how much on average your firm would have to raise its offering salary in order to hire and employ more employees of certain types. Thus, suppose your firm needed to double its present R & D and laboratory staff. In order to hire that added staff, would your firm on average have to offer 100%, 110%, or 150% of the present average R & D salary? If good R & D men are hard to find, you may have to offer a higher average salary. How much higher would the salary have to be? If good R & D staff members are in good supply and easily available, you may be able to hire them for the going rate - (100% CURRENT average salary). If good R & D men are begging to be hired, they may be willing to work for less than the going average salary (maybe 75%). Such is the information we are trying to ascertain.

The questionnaire below is organized by type of labor and material inputs on the one hand, and possible increase in staff size or material utilization on the other. In the spaces provided, please indicate how the going average salary or unit materials price might change with the indicated changes in staff size and material utilization. Express such changes as percentages of the going price or wage. One hundred percent would mean that the wage or unit price would remain the same under increased usage. Thus, under the column, "present level", the various employees are paid their current wage or salary - i.e., 100%.

As an example, Row 1) e) might read 100%, 100%, 110%, 125%, and 150%. Such a response would indicate that increasing your staff of draftsmen by one half (150%) would not be a problem given to the present availability of draftsmen. To double the staff or draftsmen, your firm would have to offer, on average, 10% higher salaries than the present salaries. To triple the staff of draftsmen, salaries 25% above the present level would have to be offered. Finally, if your firm wanted a drafting staff four times as large as its present staff, added salary offers and training expenses would amount to paying 1-1/2 times the present average salary for each new draftsman.

EXHIBIT C (CONT'D)

Increased Staff Size or Materials Utilization

	<u>Average Present Salary</u>	<u>Present Level</u>	<u>150%</u>	<u>200% Double</u>	<u>300% Triple</u>	<u>400% Quadruple</u>
1) <u>Labor</u>						
a) Administration or Management	_____	<u>100%</u>	_____	_____	_____	_____
b) Sales and Technical Service	_____	<u>100%</u>	_____	_____	_____	_____
c) Project or Design Engineering	_____	<u>100%</u>	_____	_____	_____	_____
d) R & D and Laboratory Staff	_____	<u>100%</u>	_____	_____	_____	_____
e) Draftsmen	_____	<u>100%</u>	_____	_____	_____	_____
f) Production, Mainte- nance, Operation	_____	<u>100%</u>	_____	_____	_____	_____
2) <u>Materials</u>						
a) Fabricated or Manufactured Inputs	_____	<u>100%</u>	_____	_____	_____	_____
b) Raw Material Resources	_____	<u>100%</u>	_____	_____	_____	_____

TABLE C-1
ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
MARKET: PARTICULATE CONTROL

Row	Year	(1) Base Demand Inflated Demand NW 1972 \$		(3) Annual Growth %	(4) MATERIALS OR: 90%—2 of Sales: 42		(5) (6) SKILLED LABOR OR: 60%—2 of Sales: 11		(7) (8) PRODUCTION LABOR OR: 50%—2 of Sales: 17		(9) (10) INTEREST OR: 50%—2 of Sales: 1		(11) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index	(12) (13)
					Base Inflated Cost (NW 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Cost (NW 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Cost (NW 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Cost (NW 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)		
1	1971	201	201		84		22		34		2.0			
2	1972	247	247.5	23	104		22		41.7	1.060	2.4		1.0101	1.0101
3	1973	361	376.8	46	151.6	1.005	26.30	1.120	44.2	1.060				
4	1974	570	627.4	58	239.4	1.010	29.46	1.120	2.5	1.0101				
5	1975	935	1,069.9	64	392.7	1.010	3.16	1.0088	61.0	1.125	3.6		1.0546	1.1007
6	1976	530	603.9	-43	222.6	1.005	41.52	1.125	72.8	1.193			1.0333	1.0437
7	1977	269	302.8	-49	113.0	1.005	28.61	1.0306	11.8	1.0327			1.0356	1.1443
8	1978	151	169.0	-44	63.4	1.000	58.30 ¹	1.000	96.3	1.125	5.7	2.596	.9958	1.1395
9	1979	97	107.8	-36	40.7	1.000	82.79	1.420	129.1	1.342	8.5	1.604	.9931	1.1115
10	1980	78	86.2	-20	32.8	1.000	24.49	1.0462	32.9	1.0577	3.2	1.0040	.9941	1.1049
11	1981						29.59	0.950	158.0	1.130	2.7	0.623		
12	1982						39.95	1.350	239.6	1.516	2.7	1.000		
13	1983						10.36	1.0385	81.6	1.0873	1.5			
14	1984						16.61	0.950	89.6	1.000				
15	1985						21.42	1.200	135.8	1.516				
16	1986						4.81	1.0319	46.2	1.0873				
17	1987						1.067	0.950	16.4	1.000				
18	1988						13.02	1.220	26.9	1.516				
19	1989						2.35	1.0242	8.5	1.0873				
20	1990						8.58	0.950	13.2	1.000				
21	1991						9.95	1.160	20.0	1.516				
22	1992						1.37	1.0176	6.8	1.0873				

¹ Assume return to 11% (60% operating rate) after allowing 7% at full operation (90% operating rate)

Inflated totals = 3796.3
Divided by base totals = 3639
1.0333 or 10.3% average inflation.

TABLE C-2

ANALYSIS OF POTENTIAL COST IMPACT OF THE PRICE OF POLLUTION CONTROL

CASE 11: FEDERAL COMPLIANCE SCHEDULE
(b) Adequate Gaseous Control Technology

MARKET: PARTICULATE CONTROL

Row	Year	(1) Base Demand Inflation Demand 1972 \$ I.D.	(2) Annual Growth %	(3)	MATERIALS			SKILLED LABOR			PRODUCTION LABOR			INTEREST			(12) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Index	(13) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Index
					(4) Base Inflated Δ Cost (1972 \$)	(5) Infl. Fctr. Cum. Infl. Cost Effect (Index)	(6) OR: 90%—% of Sales:42	(7) Base Infl. Fctr. Cum. Infl. Cost Effect (Index)	(8) OR: 60%—% of Sales:17	(9) Base Infl. Fctr. Cum. Infl. Cost Effect (Index)	(10) OR: 50%—% of Sales:17	(11) Base Infl. Fctr. Cum. Infl. Cost Effect (Index)	(12) OR: 50%—% of Sales:17	(13) Base Infl. Fctr. Cum. Infl. Cost Effect (Index)	(14) OR: 50%—% of Sales:17	(15) Base Infl. Fctr. Cum. Infl. Cost Effect (Index)		
1	1971	201			8.4													
2	1972																	
3	1973																	
4	1974	221	10		92.8													
5	1975	221.4																
6	1976																	
7	1977	251	14		105.4													
8	1978	252.2																
9	1979																	
10	1980	326	30		136.9	1.004												
11	1981	334.0			137.4	1.004												
12	1982				0.5	1.0015												
13	1983	496	52		208.3	1.006												
14	1984	532.5			210.4	1.010												
15	1985				2.1	1.0042												
16	1986	220	-56		92.4	0.990												
17	1987	235.4			92.4	1.000												
18	1988																	
19	1989	158	-28		66.3													
20	1990	166.9																
21	1991																	
22	1992	126	-20		52.9													
23	1993	132.3																
24	1994																	
25	1995	99	-21		41.6													
26	1996	103.4																
27	1997																	
28	1998	80	-19		33.6													
29	1999	83.3																
30	2000																	

Assume return to 11% (60% operating rate) after allowing
7% at full operation (90%)

Inflated totals = 2262.4

Divided by base totals = 2178

1.0388 or 3.9% average inflation

TABLE C-3

ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
CASE III: EXPECTED COMPLIANCE SCHEDULE
(a) Present Gasoline Control Technology

Row	Year	(2) Base Demand Inflated Demand MM 1972 \$	(3) Annual Growth %	(4) MATERIALS ON: 50%-2 of Sales: 42			(6) SKILLED LABOR ON: 60%-2 of Sales: 11			(8) PRODUCTION LABOR ON: 90%-2 of Sales: 17			(10) INTEREST ON: 50%-2 of Sales: 1			(12) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index	(13)
				Base Inflated Δ Cost	Infl. Fctr. Cum. Infl. Cost Effect	(Index)	Base Inflated Δ Cost	Infl. Fctr. Cum. Infl. Cost Effect	(Index)	Base Inflated Δ Cost	Infl. Fctr. Cum. Infl. Cost Effect	(Index)	Base Inflated Δ Cost	Infl. Fctr. Cum. Infl. Cost Effect	(Index)		
1	1971	201		84			22			34			2				
2	1971	201															
3	1971	201															
4	1972	214	7	90			22			34			2			1.0033	1.0033
5	1972	214.7								36.4	1.02						
6	1972	214.7								37.1	1.02						
7	1973	234	9	98			22			0.7	1.0033						
8	1973	235.4								39.7	1.02						
9	1973	235.4								41.3	1.04						
10	1974	281	20	118			22			1.4	1.0060						
11	1974	285.1								47.6	1.045						
12	1974	285.1								57.1	1.087						
13	1975	310	10	130						4.1	1.0146					1.0085	1.0146
14	1975	316.6								52.3	1.025						
15	1975	316.6								58.3	1.116						
16	1976	340	10	143						6.0	1.0194					1.0066	1.0213
17	1976	349.5								57.6	1.025						
18	1976	349.5								65.8	1.142						
19	1977	357	5	150						8.2	1.0241					1.0065	1.0279
20	1977	346.0								66.5	1.010						
21	1977	346.0								69.8	1.153					1.0029	1.0309
22	1978	395	11	167						9.3	1.0261						
23	1978	409.9								67.1	1.025						
24	1978	409.9								79.3	1.182					1.0066	1.0377
25	1979	441	12	187						12.2	1.0309						
26	1979	461.8								75.2	1.030						
27	1979	461.8								91.6	1.218					1.0092	1.0472
28	1980	471	7	200						16.4	1.0372						
29	1980	495.8								80.4	1.020					1.0053	1.0527
30	1980	495.8								99.9	1.242						
										19.5	1.0514						

Inflated totals = 3317.8
 Divided by base totals = 3244
 1.0289 = 2.9 average inflation.

TABLE C-4
ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
MARKET: PARTICULATE CONTROL

Row	Year	(1)	(2)	(3)	MATERIALS				SKILLED LABOR				PRODUCTION LABOR				INTEREST				(12)	(13)
					(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)		
			Base Demand Inflation Demand 1972 \$	Annual Growth %	OR: 90% - 2% of Sales: 42	OR: 60% - 2% of Sales: 11	OR: 50% - 2% of Sales: 17	OR: 50% - 2% of Sales: 1														
					Base	Infl. Fctr.	Base	Infl. Fctr.	Base	Infl. Fctr.	Base	Infl. Fctr.	Base	Infl. Fctr.	Base	Infl. Fctr.	Base	Infl. Fctr.	Base	Infl. Fctr.		
					Inflated	Cost Effect	Inflated	Cost Effect	Inflated	Cost Effect	Inflated	Cost Effect	Inflated	Cost Effect	Inflated	Cost Effect	Inflated	Cost Effect	Inflated	Cost Effect	POTENTIAL TOTAL	POTENTIAL TOTAL
					Δ Cost	(Index)	Δ Cost	(Index)	Δ Cost	(Index)	Δ Cost	(Index)	Δ Cost	(Index)	Δ Cost	(Index)	Δ Cost	(Index)	Δ Cost	(Index)	Annual Cumulative Index	Annual Cumulative Index
					(1972 \$)		(1972 \$)		(1972 \$)		(1972 \$)		(1972 \$)		(1972 \$)		(1972 \$)		(1972 \$)			
1	1971	201			84.4		22.1				34.2						2.0					
2																						
3																						
4	1972	214	6		89.9	1.0007	22.1				36.4	1.0150				2.1						1.0027
5		214.6			90.0	1.0007					36.9	1.0150										
6					0.1	1.0004					0.5	1.0023										
7	1973	234	9		98.3	1.0011	22.1				39.8	1.0225				2.3						1.0045
8		235.7			98.5	1.0018					41.3	1.0378										1.0072
9					0.2	1.0008					1.5	1.0064										
10	1974	281	20		118.0	1.0024	22.1				47.8	1.0500				2.8						1.0098
11		285.8			118.5	1.0042					52.1	1.0897										1.0171
12					0.5	1.0018					4.3	1.0153										
13	1975	310	10		130.2	1.0012	22.1				52.7	1.0250				3.1						1.0051
14		316.9			130.9	1.0054	22.6				58.9	1.1169										1.0223
15					0.7	1.0023	0.5				6.2	1.0200										
16	1976	320	3		134.4	1.0004	22.4				54.4	1.0075				3.2						1.0036
17		328.3			135.2	1.0058	23.1				61.2	1.1253										1.0260
18					0.8	1.0025	0.7				6.8	1.0213										
19	1977	285	-11		119.7	0.9942	22.4				48.5	1.0000				2.8						0.9979
20		291.8			119.7	1.0000	23.1				54.6	1.1253										1.0238
21							0.7				6.1	1.0213										
22	1978	153	-47		64.3		16.8				26.0	1.0000				1.5						0.9976
23		156.3					16.8				29.3	1.1253										1.0213
24											3.3	1.0213										
25	1979	104	-33		43.7		11.4				17.7	1.0000				1.0						1.0000
26		106.2									19.9	1.1253										1.0213
27											2.2	1.0213										
28	1980	74	-29		31.1		8.1				12.6	1.0000				0.7						1.0000
29		75.6									14.2	1.1253										1.0213
30											1.6	1.0213										

Inflated totals = 2212.2
Divided by base totals = 2176.0
1.0167 or 1.7% average inflation.

TABLE C-5

ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL

MARKET: GASEOUS CONTROL

CASE 11: FEDERAL COMPLIANCE SCHEDULE

(a) Process (9) Gaseous Control Technology (11)

(1) Row	(2) Year	(3) Base Demand Inflated Demand 1972 \$	(4) Annual Growth %	(5) MATERIALS OR: 90%—% of Sales: 46 Base Inflated Cost Effect (1972 \$)	(6) SKILLED LABOR OR: 60%—% of Sales: 10 Base Inflated Cost Effect (1972 \$)	(7) PRODUCTION LABOR OR: 90%—% of Sales: 17 Base Inflated Cost Effect (1972 \$)	(8) INTEREST OR: 30%—% of Sales: 1 Base Inflated Cost Effect (1972 \$)	(9) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index	(10) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index
1	1971	42		19.32	4.2	7.14	.42		
2	1972	42							
3	1973	50	19	23.00	4.2	8.50	-.50	1.0094	1.0094
4	1974	50.5		21.05		8.42			
5	1975	66	32	30.36	4.2	11.22	-.66		
6	1976	67.6		30.51		12.66			
7	1977	95	44	43.70	5.13 ¹	16.15	-.95	1.0144	1.0240
8	1978	101.6		44.14	6.34	20.13			
9	1979	152	60	69.92	8.20	25.86	-.95	1.0440	1.0691
10	1980	168.6		71.11	11.45	34.56			
11	1981	243	60	111.78	13.12	41.31	1.52	1.0372	1.1009
12	1982	280.7		114.46	20.71	64.36	2.63	1.0417	1.1552
13	1983	164	-33	75.44	16.40	27.88	4.86		
14	1984	191.2		75.44	25.89	44.77	1.64	1.0092	1.1658
15	1985	99	-40	45.54	9.49	16.89	2.46		
16	1986	116.1			9.90	16.83	1.750	1.0092	1.1658
17	1987	76	-23	34.96	14.85	27.02	1.606		
18	1988	87.1			6.95	10.19	1.000	1.0092	1.1658
19	1989	64	-16	29.44	7.60	12.92	1.000		
20	1990	72.8			10.83	20.76	1.606	1.0092	1.1658
21	1991				3.23	7.82	1.030		
22	1992				6.40	10.88	1.000		
23	1993				8.44	17.47	1.606		
24	1994				2.24	6.59	1.030		
25	1995								
26	1996								
27	1997								
28	1998								
29	1999								
30	2000								

¹At full operation, skilled labor becomes 5.5% of sales.

Inflated totals = 1176.2
 Divided by base totals = 1051
 1.1191 or 11.9% average inflation.

TABLE C-6
ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL

MARKET: GASEOUS CONTROL												
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Row	Year	Base Demand Inflation Demand MM 1972 \$	Annual Growth %	MATERIALS OR: 90%--2 of Sales: 46	SKILLED LABOR OR: 60%--2 of Sales: 10	PRODUCTION LABOR OR: 90%--2 of Sales: 17	INTEREST OR: 50%--2 of Sales: 1	POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index				
				Base Inflated Δ Cost (MM 1972 \$)	Base Inflated Δ Cost (MM 1972 \$)	Base Inflated Δ Cost (MM 1972 \$)	Base Inflated Δ Cost (Index)	Base Inflated Δ Cost (MM 1972 \$)	Base Inflated Δ Cost (Index)	Base Inflated Δ Cost (MM 1972 \$)	Base Inflated Δ Cost (Index)	
1	1971	42		19.3	4.2	7.1	.42					
2												
3												
4	1972	50.4	19	23.0	4.2	8.5	.50					1.0080
5						8.9						
6						0.4	1.0080					
7	1973	76	52	34.9	4.2	12.9	.76					1.0313
8		79.0		35.1	4.7	12.9						
9				0.2	0.5	15.2						
10	1974	135	78	62.1	7.4	22.9						1.0479
11		147.1		63.1	9.5	30.5						
12				1.0	2.1	7.6						1.0893
13												
14	1975	262	94	120.5	14.4	44.5						1.0313
15		297.7		124.0	21.3	67.2						
16				3.5	6.9	22.7						1.0431
17	1976	525	108	241.5	28.9	89.2						1.0482
18		625.3		251.9	49.8	133.0						
19				10.4	20.9	63.8						1.1363
20	1977	374	-29	172.0	37.4	63.6						1.1911
21		448.5		172.0	64.5	109.1						
22					27.1	45.5						1.0066
23	1978	135	-64	62.1	13.5	22.9						1.1990
24		160.0			22.1	39.3						
25					8.6	16.4						0.9885
26	1979	106	-21	48.7	10.6	18.0						1.1852
27		124.8			16.5	30.9						
28					5.9	12.9						0.9933
29	1980	94	-11	43.2	9.4	16.0						1.1772
30		109.9			13.9	27.4						
31					4.5	11.4						0.9933
32												1.1694

Assume return to 10% (60% operating rate) after allowing 5.5% at full operation (90%).

Inflated Totals = 2084.7

Divided by base totals = 1799

1. Assume return to 102 (60% operating rate) after allowing 5.5% at full operation (90%).

Inflated Totals = 2084.7
Divided by base totals = 1799

1.1588 or 15.9% average inflation

TABLE C-7

ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
CASE III: EXPECTED COMPLIANCE SCHEDULE
(a) Present Gaseous Control Technology

Row	Year	(2) Base Demand Inflated Demand MM 1972 \$	(3) Annual Growth %	(4) MATERIALS			(6) SKILLED LABOR			(7) UN- SKILLED LABOR			(8) PRODUCTION LABOR			(10) INTEREST			(12) POTENTIAL TOTAL COST IMPACT ON PRICE Annual Index	(13) POTENTIAL TOTAL COST IMPACT ON PRICE Cumulative Index
				OR: 90%—2 of Sales: 46	Base Inflated Δ Cost	(Index)	OR: 60%—2 of Sales: 10	Base Inflated Δ Cost	(Index)	OR: 50%—2 of Sales: 17	Base Inflated Δ Cost	(Index)	OR: 50%—2 of Sales: 17	Base Inflated Δ Cost	(Index)	OR: 50%—2 of Sales: 17	Base Inflated Δ Cost	(Index)		
1																				
2	1971	42		19			4			7						.42				
3		42																		
4		46		21.2			4			7.82			1.025			.46			1.0044	1.0044
5	1972	46.2	10							8.02			1.025							
6										.20			1.0044							
7		53	15	24.4			4			9.01			1.035			.53				
8	1973	53.6								9.56			1.061							
9										.55			1.0104						1.0040	1.0104
10		62	17	28.5			4			10.54			1.040			.62				
11	1974	63.1								11.63			1.103						1.0071	1.0176
12										1.09			1.0176							
13		70	13	32.2			4.67 ¹			11.90			1.03			.70			1.0074	1.0251
14	1975	71.8					4.81			13.52			1.136							
15							.16			1.62			1.0231							
16		86	23	39.6			5.74			14.62			1.06			.86			1.0164	1.0420
17	1976	89.6					6.27			17.62			1.285			.94				
18							.53			3.00			1.0349			.08				
19		108	26	49.7			7.20			18.36			1.06			1.08			1.0168	1.0596
20	1977	116.4					8.33			23.45			1.277			1.30				
21							1.13			5.09			1.0471			.22				
22		142	31	65.3			9.47			26.14			1.08			1.42			1.0236	1.0847
23	1978	156.0					11.78			33.29			1.379			1.99				
24							2.31			9.15			1.0644			.57				
25		171	20	78.7			11.40			29.07			1.05			1.71			1.0108	1.0965
26	1979	187.5					14.89			42.09			1.448			1.71				
27							3.49			13.02			1.0761			0.0				
28		208	22	95.7			13.87			35.36			1.06			2.1			1.0184	1.1167
29	1980	232.3					19.21			54.28			1.535			2.1				
30							5.34			18.92			1.0910							

¹ Skilled labor as 6.7% at 90% operating rate.

Inflated totals = 1054.5

Divided by base totals

988

1.0673 or 6.7% average inflation.

TABLE C-8
ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
CASE III: EXPECTED COMPLIANCE SCHEDULE
(b) Adequate Gaseous Control Technology

CASE III: EXPECTED COMPLIANCE SCHEDULE																
(b) Adequate Gaseous Control Technology																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)				
Row	Year	Base Demand Inflation Demand NM 1972 \$	Annual Growth %	MATERIALS			SKILLED LABOR			PRODUCTION LABOR			INTEREST			POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index
				OR: 90%--Z of Sales: 46	OR: 60%--Z of Sales: 10	OR: 90%--Z of Sales: 17	OR: 50%--Z of Sales: 1									
				Base Inflated Δ Cost	Base Inflated Δ Cost	Base Inflated Δ Cost	Base Inflated Δ Cost	Base Inflated Δ Cost	Base Inflated Δ Cost	Base Inflated Δ Cost	Base Inflated Δ Cost	Base Inflated Δ Cost				
				(NM 1972 \$)	(Index)	(NM 1972 \$)	(Index)	(NM 1972 \$)	(Index)	(NM 1972 \$)	(Index)	(Index)				
1	1971	42		19.3		4.2		7.1		0.42						
2	1972	51	21	23.5	1.0025	4.2		8.7	1.0525	0.51		1.0110				
3	1973	63	24	29.0	1.0029	4.2		9.2	1.0525							
4	1974	86	37	40.0	1.0044	4.7	1.0888	0.5	1.0098							
5	1975	90.6	31	52.0	1.0037	6.2	1.0744	10.7	1.0600	0.63		1.0222				
6	1976	113	30	52.7	1.0135	7.3	1.1698	11.9	1.1157		1.0111					
7	1977	121.2	35	67.6	1.0062	8.1	1.0097	1.2	1.0190							
8	1978	147	47	68.8	1.0036	10.2	1.0720	14.6	1.0925	0.86	1.698	1.0536				
9	1979	161.2	30	1.2	1.0071	10.2	1.2540	17.8	1.2189	1.46	1.698					
10	1980	199	35	91.5	1.0042	2.1	1.0143	3.2	1.0372	0.60	1.0070					
11	1981	224.2	35	93.5	1.0214	10.9	1.0840	19.2	1.0775	1.13	0.823	1.0730				
12	1982	292	47	134.3	1.0056	14.8	1.3593	25.2	1.3134	1.58	1.398					
13	1983	342.3	47	137.9	1.0271	3.9	1.0196	6.0	1.0531	0.45	1.0040	1.0184				
14	1984	399	47	150.4	1.0014	16.1	1.1128	25.0	1.0750	1.47	1.002	1.0966				
15	1985	405.7	47	154.7	1.0285	24.4	1.5126	35.3	1.4219	2.06	1.401					
16	1986	440.7	47	162.8	1.0131	8.3	1.0284	10.3	1.0701	0.59	1.0040					
17	1987	485.7	47	174.3	1.0006	10.0	1.0306	33.8	1.0875	1.99	1.141	1.1267				
18	1988	530.7	47	182.8	1.0291	14.8	1.3593	51.9	1.5354	3.18	1.598					
19	1989	585.7	47	194.3	1.0134	3.9	1.0196	18.1	1.0910	1.19	1.0060					
20	1990	640.7	47	202.8	1.0271	16.1	1.1128	49.6	1.1175	2.92	1.252	1.1723				
21	1991	695.7	47	211.3	1.0271	24.4	1.5126	85.1	1.7158	5.84	2.000					
22	1992	750.7	47	220.8	1.0123	8.3	1.0284	35.5	1.1216	2.92	1.0100					
23	1993	805.7	47	230.3	1.0014	18.0	1.0288	55.6	1.0300	3.27	0.749	1.1793				
24	1994	860.7	47	240.8	1.0285	28.0	1.5562	98.3	1.7673	4.90	1.498					
25	1995	915.7	47	251.3	1.0131	10.0	1.0306	42.7	1.1306	1.63	1.0050					
26	1996	970.7	47	261.8	1.0006	18.9	1.0120	58.5	1.0125	3.44	0.668	1.1794				
27	1997	1025.7	47	272.3	1.0291	29.8	1.5749	104.7	1.7894	3.44	1.000					
28	1998	1080.7	47	282.8	1.0134	10.9	1.0317	46.2	1.1343							
29	1999	1135.7	47	293.3	1.0006	18.9	1.0120	58.5	1.0125							
30	2000	1190.7	47	303.8	1.0291	29.8	1.5749	104.7	1.7894							
31	2001	1245.7	47	314.3	1.0134	10.9	1.0317	46.2	1.1343							
32	2002	1300.7	47	324.8	1.0006	18.9	1.0120	58.5	1.0125							
33	2003	1355.7	47	335.3	1.0291	29.8	1.5749	104.7	1.7894							
34	2004	1410.7	47	345.8	1.0134	10.9	1.0317	46.2	1.1343							
35	2005	1465.7	47	356.3	1.0006	18.9	1.0120	58.5	1.0125							
36	2006	1520.7	47	366.8	1.0291	29.8	1.5749	104.7	1.7894							
37	2007	1575.7	47	377.3	1.0134	10.9	1.0317	46.2	1.1343							
38	2008	1630.7	47	387.8	1.0006	18.9	1.0120	58.5	1.0125							
39	2009	1685.7	47	398.3	1.0291	29.8	1.5749	104.7	1.7894							
40	2010	1740.7	47	408.8	1.0134	10.9	1.0317	46.2	1.1343							
41	2011	1795.7	47	419.3	1.0006	18.9	1.0120	58.5	1.0125							
42	2012	1850.7	47	429.8	1.0291	29.8	1.5749	104.7	1.7894							
43	2013	1905.7	47	440.3	1.0134	10.9	1.0317	46.2	1.1343							
44	2014	1960.7	47	450.8	1.0006	18.9	1.0120	58.5	1.0125							
45	2015	2015.7	47	461.3	1.0291	29.8	1.5749	104.7	1.7894							
46	2016	2070.7	47	471.8	1.0134	10.9	1.0317	46.2	1.1343							
47	2017	2125.7	47	482.3	1.0006	18.9	1.0120	58.5	1.0125							
48	2018	2180.7	47	492.8	1.0291	29.8	1.5749	104.7	1.7894							
49	2019	2235.7	47	503.3	1.0134	10.9	1.0317	46.2	1.1343							
50	2020	2290.7	47	513.8	1.0006	18.9	1.0120	58.5	1.0125							
51	2021	2345.7	47	524.3	1.0291	29.8	1.5749	104.7	1.7894							
52	2022	2400.7	47	534.8	1.0134	10.9	1.0317	46.2	1.1343							
53	2023	2455.7	47	545.3	1.0006	18.9	1.0120	58.5	1.0125							
54	2024	2510.7	47	555.8	1.0291	29.8	1.5749	104.7	1.7894							
55	2025	2565.7	47	566.3	1.0134	10.9	1.0317	46.2	1.1343							
56	2026	2620.7	47	576.8	1.0006	18.9	1.0120	58.5	1.0125							
57	2027	2675.7	47	587.3	1.0291	29.8	1.5749	104.7	1.7894							
58	2028	2730.7	47	597.8	1.0134	10.9	1.0317	46.2	1.1343							
59	2029	2785.7	47	608.3	1.0006	18.9	1.0120	58.5	1.0125							
60	2030	2840.7	47	618.8	1.0291	29.8	1.5749	104.7	1.7894							
61	2031	2895.7	47	629.3	1.0134	10.9	1.0317	46.2	1.1343							
62	2032	2950.7	47	639.8	1.0006	18.9	1.0120	58.5	1.0125							
63	2033	3005.7	47	650.3	1.0291	29.8	1.5749	104.7	1.7894							
64	2034	3060.7	47	660.8	1.0134	10.9	1.0317	46.2	1.1343							
65	2035	3115.7	47	671.3	1.0006	18.9	1.0120	58.5	1.0125							
66	2036	3170.7	47	681.8	1.0291	29.8	1.5749	104.7	1.7894							
67	2037	3225.7	47	692.3	1.0134	10.9	1.0317	46.2	1.1343							
68	2038	3280.7	47	702.8	1.0006	18.9	1.0120	58.5	1.0125							
69	2039	3335.7	47	713.3	1.0291	29.8	1.5749	104.7	1.7894							
70	2040	3390.7	47	723.8	1.0134	10.9	1.0317	46.2	1.1343							
71	2041	3445.7	47	734.3	1.0006	18.9	1.0120	58.5	1.0125							
72	2042	3500.7	47	744.8	1.0291	29.8	1.5749	104.7	1.7894							
73	2043	3555.7	47	755.3	1.0134	10.9	1.0317	46.2	1.1343							
74	2044	3610.7	47	765.8	1.0006	18.9	1.0120	58.5	1.0125							
75	2045	3665.7	47	776.3	1.0291	29.8	1.5749	104.7	1.7894							
76	2046	3720.7	47	786.8	1.0134	10.9	1.0317	46.2	1.1343							
77	2047	3775.7	47	797.3	1.0006	18.9	1.0120	58.5	1.0125							
78	2048	3830.7	47	807.8	1.0291	29.8	1.5749	104.7	1.7894							
79	2049	3885.7	47	818.3	1.0134	10.9	1.0317	46.2	1.1343							
80	2050	3940.7	47	828.8	1.0006	18.9	1.0120	58.5	1.0125							
81	2051	3995.7	47	839.3	1.0291	29.8	1.5749	104.7	1.7894							
82	2052	4050.7	47	849.8	1.0134	10.9	1.0317	46.2	1.1343							
83	2053	4105.7	47	860.3	1.0006	18.9	1.0120	58.5	1.0125							
84	2054	4160.7	47	870.8	1.0291	29.8	1.5749	104.7	1.7894							
85	2055	4215.7	47	881.3	1.0134	10.9	1.0317	46.2	1.1343							
86	2056	4270.7	47	891.8	1.0006	18.9	1.0120	58.5	1.0125							
87	2057	4325.7	47	902.3	1.0291	29.8	1.5749	104.7	1.7894							
88	2058	4380.7	47	912.8	1.0134	10.9	1.0317	46.2	1.1343							
89	2059	4435.7	47	923.3	1.0006	18.9	1.0120	58.5	1.0125							
90	2060	4490.7	47	933.8	1.0291	29.8	1.5749	104.7	1.7894							
91	2061	4545.7	47	944.3	1.0134	10.9	1.0317	46.2	1.1343							
92	2062	4600.7	47	954.8	1.0006	18.9	1.0120	58.5	1.0125							
93	2063	4655.7	47	965.3	1.0291	29.8	1.5749	104.7	1.7894							
94	2064	4710.7	47	975.8	1.0134	10.9	1.0317	46.2	1.1343							
95	2065	4765.7	47	986.3	1.0006	18.9	1.0120	58.5	1.0125							
96	2066	4820.7	47	996.8	1.0291	29.8	1.5749	104.7	1.7894							
97	2067	4875.7	47	1007.3	1.0134	10.9	1.0317	46.2	1.1343							
98	2068	4930.7	47	1017.8	1.0006	18.9	1.0120	58.5	1.0125							
99	2069	4985.7	47	1028.3	1.0291	29.8	1.5749	104.7	1.7894							
100	2070	5040.7	47	1038.8	1.0134	10.9	1.0317	46.2	1.1343							
101	2071	5095.7	47	1049.3	1.0006	18.9	1.0120	58.5	1.0125							
102	2072	5150.7	47	1059.8	1.0291	29.8	1.5749	104.7	1.7894							
103	2073	5205.7	47	1070.3	1.0134	10.9	1.0317	46.2	1.1343							
104	2074	5260.7	47	1080.8	1.0006	18.9	1.0120	58.5	1.0125							

TABLE C-9

**ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
CASE 1: BASELINE**

MARSH: WATER POLLUTION CONTROL EQUIPMENT

Row	Year	(1) Base Demand (Market) Inflated Demand MM 1972 \$	(2) Annual Growth %	(3)	(4) MATERIALS OR: 1-2 of Sales: 54			(5) SKILLED LABOR OR: 602-2 of Sales: 10			(6) PRODUCTION LABOR OR: 902-2 of Sales: 13			(7) INTEREST OR: 402-2 of Sales: 1			(12)	(13)
					Base Inflated Δ Cost	Infl. Petr. Cum. Infl. Cost Effect	(Index)	Base Inflated Δ Cost	Infl. Petr. Cum. Infl. Cost Effect	(Index)	Base Inflated Δ Cost	Infl. Petr. Cum. Infl. Cost Effect	(Index)	Base Inflated Δ Cost	Infl. Petr. Cum. Infl. Cost Effect	(Index)		
1	1971	152 + (200)			190.1			35.2			45.8			3.5				
2	1972	152																
3	1973	159 + (206)	3.7		197.1			35.2			47.5			3.6			1.0007	1.0007
4	1974	159.1									47.6							
5	1975	167 + (212)	3.7		220.9			35.2			49.3			4.1			1.0006	1.0013
6	1976	167.3									49.6							
7	1977	175 + (219)	3.8		229.0			35.2			51.2			4.2			1.0007	1.0020
8	1978	175.5									51.7							
9	1979	183 + (225)	3.8		220.3			35.2			53.0			4.1			1.0006	1.0026
10	1980	183.5									53.5							
11	1981	192 + (232)	3.9		229.0			35.2			55.1			4.2			1.0007	1.0033
12	1982	192.6									55.7							
13	1983	202 + (239)	3.9		238.1			35.2			57.3			4.4			1.0006	1.0039
14	1984	202.8									58.1							
15	1985	213 + (246)	4.0		247.9			35.2			59.7			4.6			1.0007	1.0046
16	1986	216.0									60.7							
17	1987	224 + (253)	4.0		257.6			35.2			62.0			4.8			1.0007	1.0053
18	1988	225.2									63.2							
19	1989	236 + (261)	4.1		268.4			35.2			64.6			5.0			1.0007	1.0060
20	1990	237.4									66.0						1.0007	1.0060
21											1.4							

Inflated totals = 1909.4
Divided by base totals 1903
1.0034 or 0.3% average inflation.

TABLE C-10

ANALYSIS OF POTENTIAL COST IMPACT IN THE PRICE OF POLLUTION CONTROL
CASE II: FEDERAL COMPLIANCE SCHEDULE

MARSET: WATER POLLUTION CONTROL EQUIPMENT

Row	Year	(1) Base Demand + (water) Inflated Demand NM 1972 \$	(2) Annual Growth %	(3) Annual Growth %	(4) MATERIALS		(5) SKILLED LABOR		(6) PRODUCTION LABOR		(7) INTEREST		(12) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index	(13) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index
					OR: 1--2 of Sales: 54 Base Inflated Δ Cost (NM 1972 \$)	Infl. Fctr. Cum. Infl. Cost Effect (Index)	OR: 60%--2 of Sales: 10 Base Inflated Δ Cost (NM 1972 \$)	Infl. Fctr. Cum. Infl. Cost Effect (Index)	OR: 90%--2 of Sales: 13 Base Inflated Δ Cost (NM 1972 \$)	Infl. Fctr. Cum. Infl. Cost Effect (Index)	OR: 50%--2 of Sales: 1 Base Inflated Δ Cost (NM 1972 \$)	Infl. Fctr. Cum. Infl. Cost Effect (Index)		
1	1971	282 + (200)			260.3		48.2		62.7		4.8			
2	1971	282												
3	1971													
4	1972	318 + (206)	8.7		283.0		48.2		68.1	1.010	5.2		1.0013	1.0013
5	1972	318.4							68.8	1.010				
6	1972								.7	1.0013				
7	1973	370 + (212)	11.1		314.3		48.2		75.7	1.010	5.8		1.0013	1.0026
8	1973	370.9							77.2	1.020				
9	1973								1.5	1.0026				
10	1974	439 + (219)	13.1		355.3		48.2		85.5	1.015	6.6		1.0020	1.0046
11	1974	441.0							88.5	1.035				
12	1974								3.0	1.0046				
13	1975	531 + (225)	14.9		408.2		50.4	1.035	98.3	1.015	7.6		1.0043	1.0090
14	1975	535.8					52.2	1.035	103.3	1.051				
15	1975						1.8	1.0024	5.0	1.0066				
16	1976	616 + (232)	12.2		457.9		56.6	1.030	110.2	1.015	8.5		1.0040	1.0131
17	1976	624.1					60.3	1.066	117.6	1.067				
18	1976						3.7	1.0044	7.4	1.0087				
19	1977	451 + (239)	(19)		372.6		56.6	1.000	89.7	1.000	6.9		1.0010	1.0141
20	1977	457.4					60.3	1.066	95.7	1.067				
21	1977						3.7	1.0054	6.0	1.0087				
22	1978	296 + (246)	(21)		292.7		54.2	.950	70.5	1.000	5.4		0.9960	1.0100
23	1978	299.0					54.9	1.013	75.2	1.067				
24	1978						.7	1.0013	4.7	1.0087				
25	1979	188 + (253)	(19)		238.1		44.1	.987	57.3	1.000	4.4		0.9990	1.0087
26	1979	189.6					44.1	1.000	61.1	1.067				
27	1979						3.8		3.8	1.0087				
28	1980	136 + (261)	(10)		214.4		39.7		51.6	1.000	4.0		1.000	1.0087
29	1980	137.2							55.1	1.067				
30	1980								3.5	1.0087				

Inflated total = 3655.4
 Divided by base totals 3627
 1.0078 or 0.8% average inflation.

TABLE C-11

ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
MARKET: WATER POLLUTION CONTROL EQUIPMENT

CASE III: EXPECTED COMPLIANCE SCHEDULE

(1) Row Year	(2) Base Demand + (Water) Inflated Demand MM 1972 \$	(3) Annual Growth %	(4) MATERIALS OR: 2-2 of Sales: 54		(6) SKILLED LABOR OR: 602-2 of Sales: 10		(7) PRODUCTION LABOR OR: 902-2 of Sales: 13		(9) INTEREST OR: 502-2 of Sales: 1		(12) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Index	(13) POTENTIAL TOTAL COST EFFECT ON PRICE Cumulative Index
			Base Inflated Δ Cost (MM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Δ Cost (MM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Δ Cost (MM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Δ Cost (MM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)		
1 1971	282 + (200)		282		48.2		62.7		4.8			
2 1972	298 + (206)	4.6	298.2		48.2		65.5	1.005	5.0		1.0006	1.0006
3 1973	320 + (212)	5.6	320.4		48.2		69.2	1.005	5.3		1.0007	1.0013
4 1974	359 + (219)	8.6	359.9		48.2		75.1	1.010	5.8		1.0013	1.0026
5 1975	399 + (225)	8.0	399.5		48.2		81.1	1.010	6.2		1.0012	1.0038
6 1976	439 + (232)	7.5	439.4		48.2		87.2	1.010	6.7		1.0015	1.0054
7 1977	437 + (239)	0.7	439.4		48.2		90.8	1.041	6.7		1.000	1.0054
8 1978	379 + (246)	(8.5)	381.0		48.2		87.9	1.000	6.3		1.000	1.0054
9 1979	357 + (253)	(2.4)	359.0		48.2		84.6	1.041	6.1		1.000	1.0054
10 1980	366 + (261)	2.8	366.2		48.2		82.6	1.041	6.3		1.0005	1.0059
11 1981							81.5	1.005				
12 1982							85.2	1.046				
13 1983							3.7	1.0059				
			Inflated totals = 3648									
			Divided by base totals									
			1.0033 or 0.3% average inflation.									

TABLE C-12

ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
CASE 11: FEDERAL COMPLIANCE SCHEDULE

MARKET: INSTRUMENTATION

Row	(1) Year	(2) Base Demand Inflated Demand MM 1972 \$	(3) Annual Growth %	(4) MATERIALS OR: 2-2 of Sales: 34 Base Inflated Δ Cost (MM 1972 \$)	(5) SKILLED LABOR OR: 652-2 of Sales: 34 Base Infl. Fctr. Cum. Infl. Cost Effect (Index)	(6) SKILLED LABOR OR: 652-2 of Sales: 34 Base Inflated Δ Cost (MM 1972 \$)	(7) SKILLED LABOR OR: 652-2 of Sales: 34 Base Infl. Fctr. Cum. Infl. Cost Effect (Index)	(8) PRODUCTION LABOR OR: 907-2 of Sales: 18 Base Inflated Δ Cost (MM 1972 \$)	(9) PRODUCTION LABOR OR: 907-2 of Sales: 18 Base Infl. Fctr. Cum. Infl. Cost Effect (Index)	(10) INTEREST OR: 607-2 of Sales: 11 Base Inflated Δ Cost (MM 1972 \$)	(11) INTEREST OR: 607-2 of Sales: 11 Base Infl. Fctr. Cum. Infl. Cost Effect (Index)	(12) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Index	(13) POTENTIAL TOTAL COST EFFECT ON PRICE Cumulative Index
1													
2	1971	58		19.7		12.75		10.44		0.64			
3		58											
4		80	38.0	27.2		12.75		14.44	1.040	0.88		1.0073	1.0073
5	1972	80.6						15.02	1.040				
6								.58	1.0073				
7		103	29.0	35.0		16.35	1.035	18.34	1.030	1.13	2.009		
8	1973	106.0				16.92	1.035	19.86	1.071	2.27	2.009		
9						.57	1.0055	1.32	1.0128	1.14	1.0111		
10		139	35.0	47.2		22.07	1.045	25.02	1.035	1.53	1.265		
11	1974	145.9				23.88	1.082	27.72	1.108	3.89	2.542		
12						1.81	1.0130	2.70	1.0194	2.36	1.0170		1.0494
13		198	42.5	67.3		31.44	1.055	35.64	1.045	2.18	1.072		
14	1975	211.9				35.90	1.142	41.27	1.158	5.94	2.725		
15						4.46	1.0225	5.63	1.0284	3.76	1.0190		1.0699
16		202	2.0	68.7		32.07	1.000	36.36	1.000	2.22	.688		
17	1976	214.1				36.62	1.142	42.10	1.158	4.04	1.820		1.0599
18						4.55	1.0225	5.74	1.0284	1.82	1.0090		
19		142	(29.7)	48.3		27.00 ¹	1.030	25.56	1.000	1.56	.549		
20	1977	149.9				30.83	1.142	29.60	1.158	1.56	1.000		1.0554
21						3.83	1.0270	4.04	1.0284	0.0	0.0		
22		98	(31.0)	33.3		21.56 ²	.950	17.64	1.000	1.08			
23	1978	102.6				23.39	1.085	20.43	1.158				1.0472
24						1.83	1.0187	2.79	1.0285				
25		58	(40.8)	19.7		12.76	.950	10.44	1.000	0.64			
26	1979	60.0				13.16	1.031	12.09	1.158				1.0353
27						.40	1.0069	1.65	1.0284				
28		45	(22.4)	15.3		9.90	.970	8.10	1.000	0.50			
29	1980	46.3				9.90	1.000	9.38	1.158				1.0284
30						0.0		1.28	1.0284				

¹ Operating rate declines to 80%
² Operating rate declines to 65%.

Inflated totals = 1175.3
 Divided by base totals = 1123
 1.0466 or 4.6% average inflation.

TABLE C-13

ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
CASE III: EXPECTED COMPLIANCE SCHEDULE

MARKET: INSTRUMENTATION

Row	Year	(2) Base Demand Inflated Demand NM 1972 \$	(3) Annual Growth %	(4) MATERIALS OR: 2--2 of Sales: 34			(6) SKILLED LABOR OR: 65%--2 of Sales: 22			(8) PRODUCTION LABOR OR: 90%--2 of Sales: 18			(10) INTEREST OR: 40%--2 of Sales: 1.1			(12) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index	(13) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index
				Base Inflated Δ Cost (NM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Δ Cost (NM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Δ Cost (NM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Δ Cost (NM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Δ Cost (NM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)	Base Inflated Δ Cost (NM 1972 \$)	Infl. Petr. Cum. Infl. Cost Effect (Index)		
1																	
2	1971	58		19.72		12.76		10.44		0.64							
3		58															
4		69	19.0	23.46		12.76											
5	1972	69.2															
6																	
7		78	13.1	26.52		12.76											
8	1973	78.5															
9																	
10		91	16.7	30.94		12.94											
11	1974	92.2				13.20											
12						0.26											
13		109	19.7	37.06		13.50											
14	1975	111.5				16.21											
15						0.71											
16		126	13.6	42.84		17.93											
17	1976	129.3				19.11											
18						1.18											
19		137	8.7	46.58		19.50											
20	1977	140.9				21.00											
21						1.50											
22		138	0.8	46.42		19.64											
23	1978	142.0				21.15											
24						1.51											
25		148	7.2	50.32		21.06											
26	1979	152.6				22.91											
27						1.85											
28		164	10.8	55.76		23.34											
29	1980	169.8				25.77											
30						2.43											

Inflated totals = 1144
 Divided by base totals 1118
 1.0232 or 2.32 average inflation.

TABLE C-14

**ANALYSIS OF POTENTIAL COST IMPACT ON THE PRICE OF POLLUTION CONTROL
MARKET: SPECIALTY CHEMICALS**

CASE 111 (6-111): EXPECTED COMPLIANCE SCHEDULE
FEDERAL COMPLIANCE SCHEDULE

Row	Year	(1) Base Demand Inflated Demand MM 1972 \$	(2) Annual Growth %	(3)	(4) MATERIALS OR: 90%--2 of Sales: 4.7			(5) SKILLED LABOR OR: 60%--2 of Sales: 9.5			(6) PRODUCTION LABOR OR: 90%--2 of Sales: 6.5			(7) INTEREST OR: 60%--2 of Sales: 1.5			(12) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index	(13) POTENTIAL TOTAL COST EFFECT ON PRICE Annual Cumulative Index
					Base Inflated Cost	Infl. Fctr. Cum. Infl. Cost Effect	(Index)	Base Inflated Cost	Infl. Fctr. Cum. Infl. Cost Effect	(Index)	Base Inflated Cost	Infl. Fctr. Cum. Infl. Cost Effect	(Index)	Base Inflated Cost	Infl. Fctr. Cum. Infl. Cost Effect	(Index)		
1	1971	275			129			26.1			17.9			4.1				
2	1971	275																
3																		
4	1972	289	5		136			26.1			18.8			4.3			1.0003	1.0003
5	1972	289.1									18.9							
6											.1							
7	1973	305	5		143			26.1			19.8			4.6			1.0003	1.0006
8	1973	305.2									1.005							
9											4.0100							
10	1974	320	5		150			26.1			.2			4.8			1.0003	1.0009
11	1974	320.3									20.8							
12											21.1							
13	1975	336	5		158			26.1			.3			5.0			1.0003	1.0012
14	1975	336.4									21.8							
15											22.2							
16	1976	354	5		166			26.1			.4			5.3			1.0004	1.0016
17	1976	354.5									23.0							
18											23.5							
19	1977	371	5		174			26.1			.5			5.6			1.0004	1.0020
20	1977	371.7									24.1							
21											24.8							
22	1978	388	4.5		182			27.2	1.006		25.2			5.8			1.0011	1.0031
23	1978	389.2						27.5	1.0115		26.1							
24								.3	1.0008		.9							
25	1979	403	4		189			28.2	1.0055		26.2			6.0			1.0007	1.0038
26	1979	404.6						28.7	1.0171		27.2							
27								.5	1.0012		1.1							
28	1980	418	4		196			29.3	1.0055		27.2			6.3			1.0007	1.0045
29	1980	420.0						30.0	1.0227		28.4							
30								.7	1.0016		1.2							

Inflated totals = 2466
Divided by base totals = 2439
1.00202 or 0.2% average inflation.

TABLE C-15

SALES/EMPLOYEE RATIOS: APC EQUIPMENT-PARTICULATE REMOVAL

		<u>Sales/Employee</u> <u>(\$1,000)</u>
A. "IN"	American Air Filter	28.3
	Envirotech	33.8
	Buffalo Forge	25.9
	Carborundum	19.6
	Joy Mfg.	29.6
	Peabody-Galton	30.0
	Research-Cottrell	60.6
	Wheelabrator-Frye	40.0
	Zurn	33.8
	Slick	12.6
B. "NEAR"	Combustion Engineering	32.2
	General American	
	Transportation	33.0
	Foster Wheeler	34.9
	Koppers	38.4

SOURCE: Moody's Industrial Manual

TABLE C-16

SALES/EMPLOYEE RATIOS: APC EQUIPMENT-GASEOUS CONTROL

		<u>Sales/Employee</u> <u>(\$1,000)</u>
A. "NEAR"	Combustion Engineering	32.2
	Midland-Ross	27.0
	Monsanto	35.2
	Peabody-Galion	30.0
	Research-Cottrell	60.6
	Sunbeam	23.5
	Foster-Wheeler	34.9
	Babcock & Wilcox	26.3
	Zurn	33.8

SOURCE: Moody's Industrial Manual

TABLE C-17

SALES/EMPLOYEE RATIO - WPC EQUIPMENT

		<u>Sales/Employee</u> <u>(\$1,000)</u>
A. "IN"	Clow	33.0
	Dorr-Oliver	31.3
	Envirotech	33.8
	Marley	38.5
	Pennwalt	31.3
	Rex Chainbelt	27.3
	Ecodyne	51.3
B. "NEAR"	Chicago Bridge & Iron	36.6
	Merck	36.4
	Crane	28.3
	Dravo	48.2
	FMC	29.7
	Research-Cottrell	60.6
	Singer	38.1
	Sunbeam	23.5
	Sybron	24.3
	Westinghouse	29.7

SOURCE: Moody's Industrial Manual

TABLE C-18

SALES/EMPLOYEE RATIO: APC AND WPC INSTRUMENTATION

	<u>Sales/Employee</u> <u>(\$1,000)</u>
A. "IN"	
Beckman	19.7
Fischer & Porter (1972)	20.0
Foxboro	19.3
General Signal	24.3
Leeds & Northrup	21.3
Technicon	34.7
B. "NEAR"	
Envirotech	33.8
Sybron	24.3
Honeywell	20.6
Litton	21.3

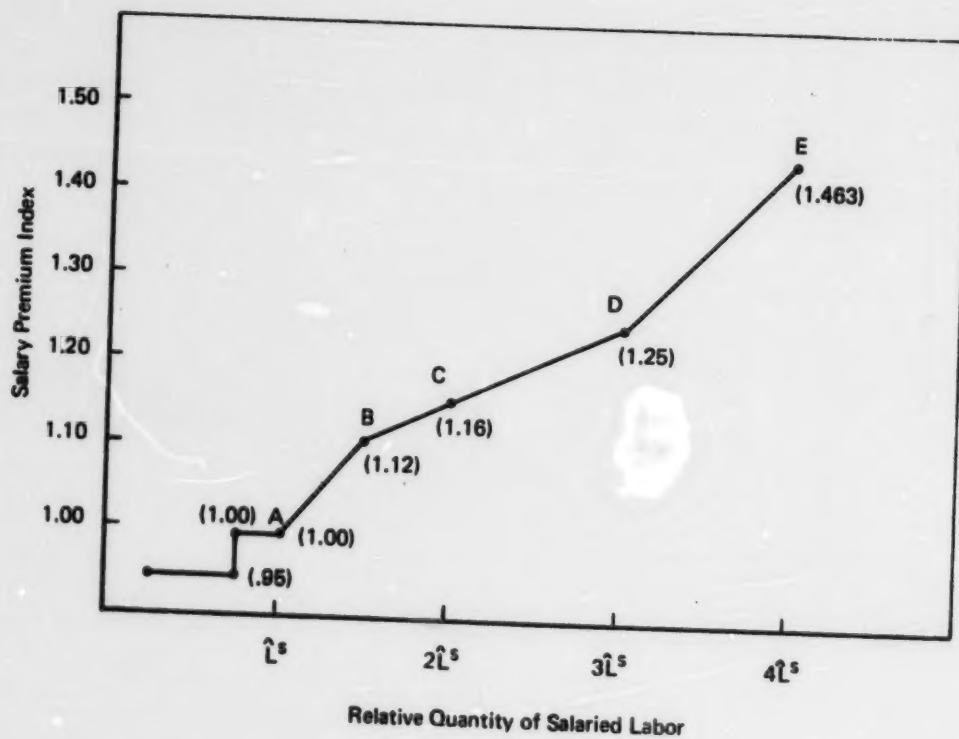
SOURCE: Moody's Industrial Manual

TABLE C-19

SALES/EMPLOYEE RATIO: WPC-SPECIALTY CHEMICALS

		<u>Sales/Employee</u> <u>(\$1,000)</u>
A. "IN"	Betz	39.2
	Chemed	30.0
	Mogul	13.1
	Nalco	67.2
	Calgon (1966)	42.9
B. "NEAR"	Dow	42.9
	DuPont	36.1
	Hercules	38.4
	Merck	36.4
	Monsanto	35.2
	Olin	38.2
	Union Carbide	30.6
	Drew (Slick)	75.9

SOURCE: Moody's Industrial Manual



Elasticities:

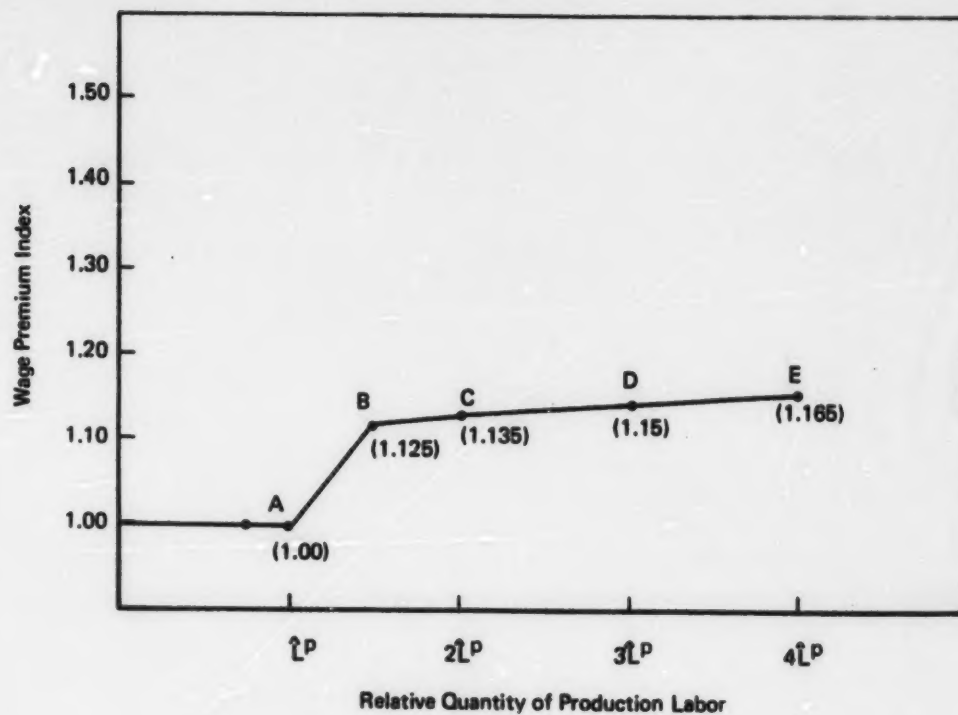
A-B:	4.2
B-C:	9.2
C-D:	6.4
D-E:	1.9

Notes:

$\hat{L}^s$ represents the current level of salaried labor utilization; $2\hat{L}^s$ represents the 200% level, etc.

The Salary Premium Index indicates the salary premium required to obtain additional labor.

FIGURE C-1 PARTICULATE AND GASEOUS EQUIPMENT
a) Salaried Labor



Elasticities:

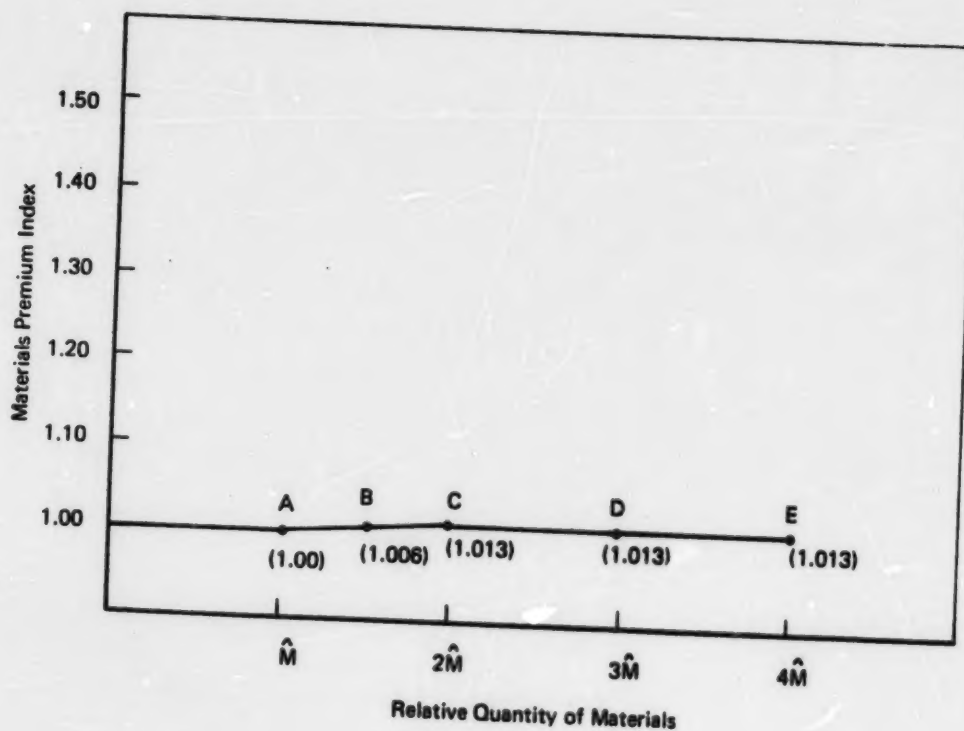
A-B: 4.0
 B-C: 37.1
 C-D: 37.9
 D-E: 25.4

Notes:

$1\hat{L}^P$ represents current levels of production labor utilization; $2\hat{L}^P$ represents the 200% level, etc.

The Wage Premium Index indicates the unit wage premium required to obtain additional production labor.

FIGURE C-1 PARTICULATE AND GASEOUS EQUIPMENT
b) Production Labor



Elasticities:

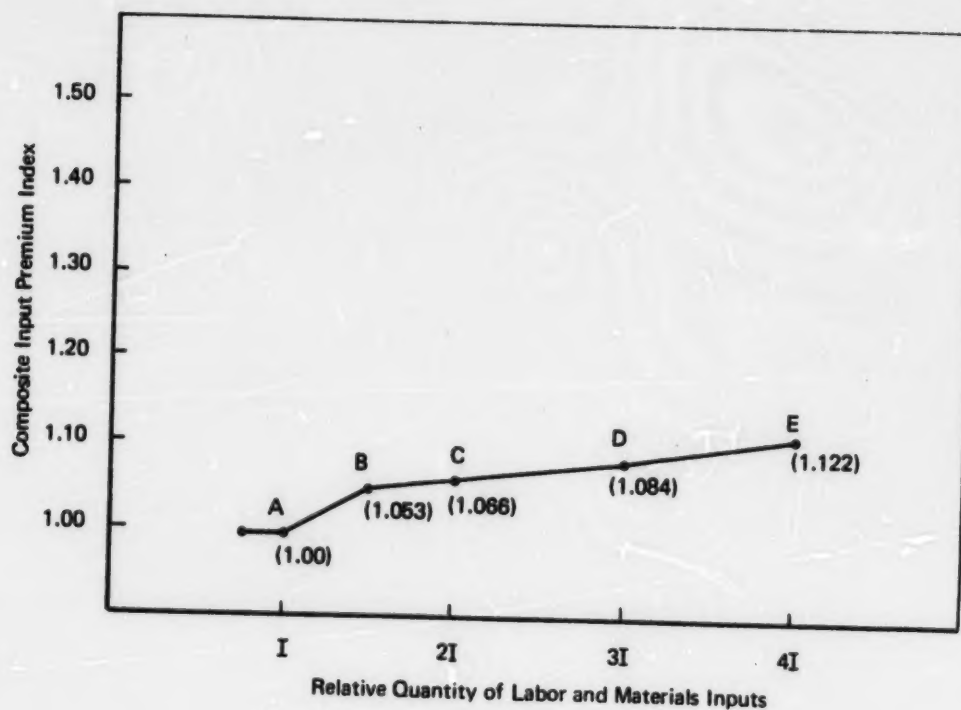
A-B:	83.3
B-C:	47.1
C-D:	∞
D-E:	∞

Notes:

$\hat{M}$ represents current levels of materials utilization; $2\hat{M}$ represents the 200% level, etc.

The Materials Premium Index indicates the unit premium required to obtain additional materials.

FIGURE C-1 PARTICULATE AND GASEOUS EQUIPMENT
c) Materials



Elasticities:

A-B:	9.4
B-C:	26.8
C-D:	29.6
D-E:	12.8

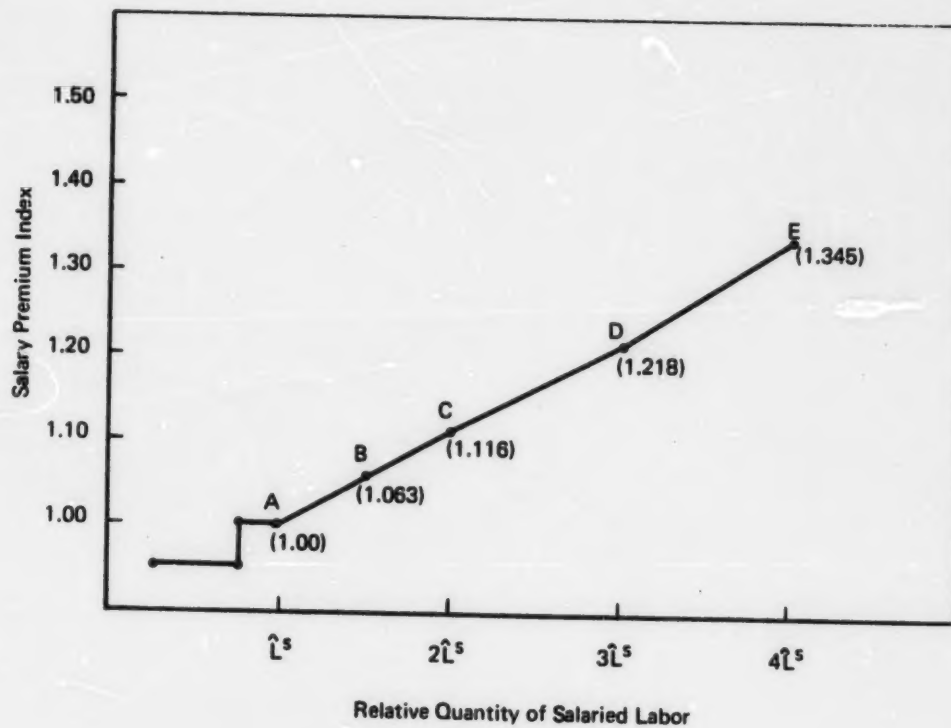
Notes:

I represents current levels of input utilization; 2I represents the 200% level, etc.
 The Composite Input Premium Index indicates the unit premium that must be paid to obtain increased amounts of inputs (labor and materials).

Relative weights from 1967 Census of Manufactures and industry sources:

Salaried Labor:	.16
Production Labor:	.24
Materials:	.60

FIGURE C-1 PARTICULATE AND GASEOUS EQUIPMENT
d) Composite Supply Curves: Labor and Materials



Elasticities:

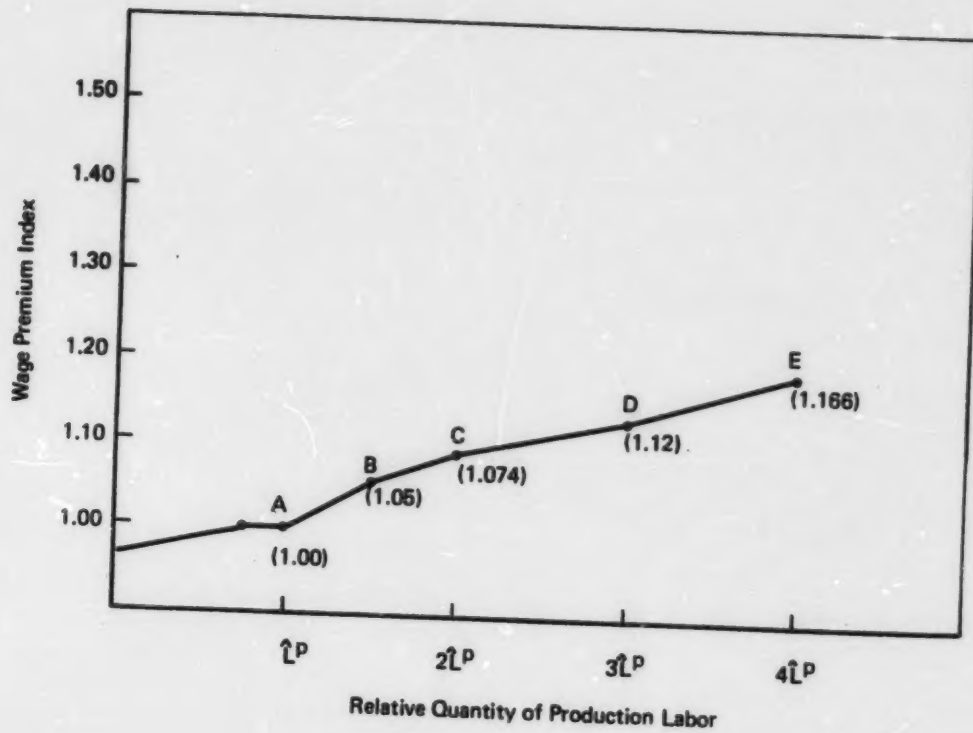
A-B:	7.9
B-C:	6.6
C-D:	5.5
D-E:	3.2

Notes:

$\hat{L}^s$ represents the current level of salaried labor utilization; $2\hat{L}^s$ represents the 200% level, etc.

The Salary Premium Index indicates the salary premium required to obtain additional labor.

FIGURE C-2 AIR AND WATER INSTRUMENTATION
a) Salaried Labor



Elasticities:

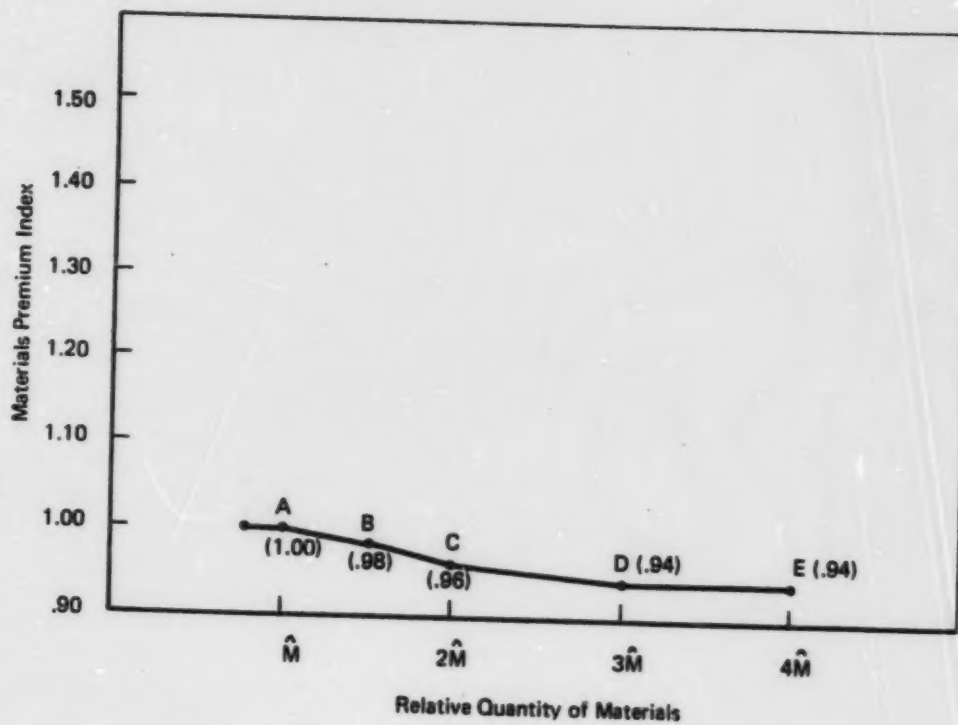
A-B:	10.0
B-C:	14.4
C-D:	11.7
D-E:	8.0

Notes:

$\hat{L}^P$ represents current levels of production labor utilization; $2\hat{L}^P$ represents the 200% level, etc.

The Wage Premium Index indicates the unit wage premium required to obtain additional production labor.

FIGURE C-2 AIR AND WATER INSTRUMENTATION
b) Production Labor



Elasticities:

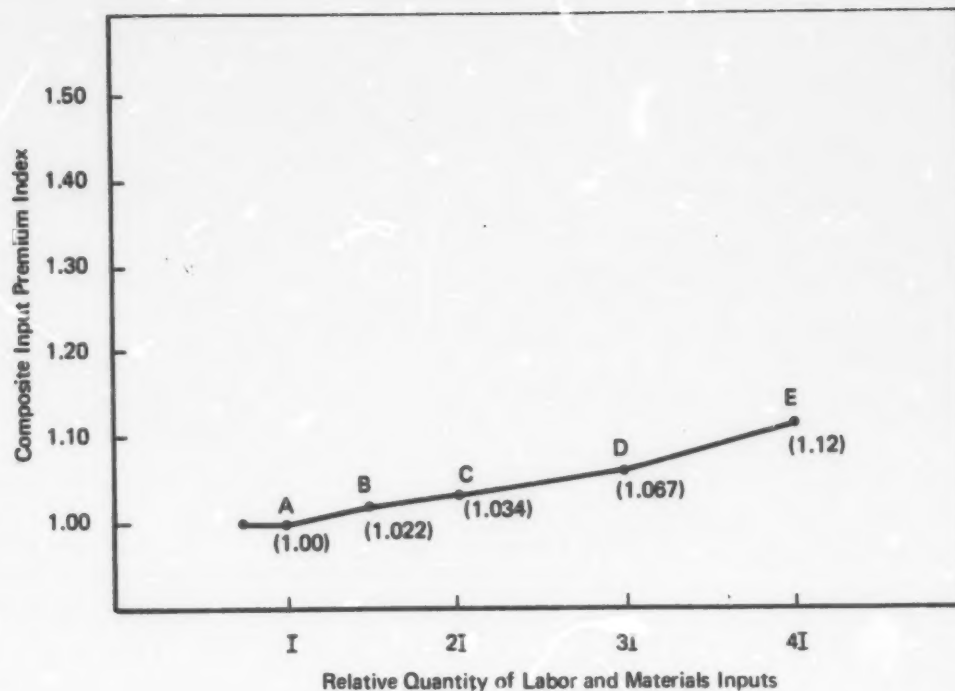
A-B: -25.0
 B-C: -16.2
 C-D: -24.0
 D-E: ∞

Notes:

$\hat{M}$ represents current levels of materials utilization; $2\hat{M}$ represents the 200% level, etc.

The Materials Premium Index indicates the unit premium required to obtain additional materials.

FIGURE C-2 AIR AND WATER INSTRUMENTATION
 c) Materials



Elasticities:

A-B:	22.7
B-C:	28.2
C-D:	15.7
D-E:	6.6

Notes:

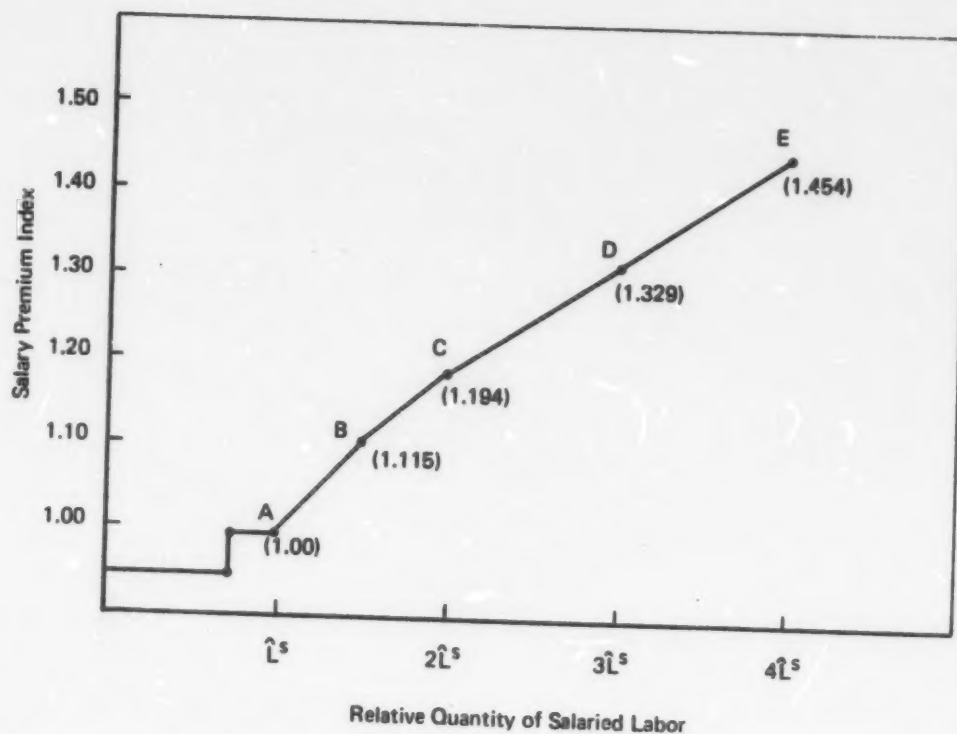
I represents current levels of input utilization; 2I represents the 200% level, etc.

The Composite Input Premium Index indicates the unit premium that must be paid to obtain increased amounts of inputs (labor and materials).

Relative weights from 1967 Census of Manufactures and industry sources:

Salaried Labor:	.30
Production Labor:	.24
Materials:	.46

FIGURE C-2 AIR AND WATER INSTRUMENTATION
d) Composite Supply Curve: Labor and Materials



Elasticities:

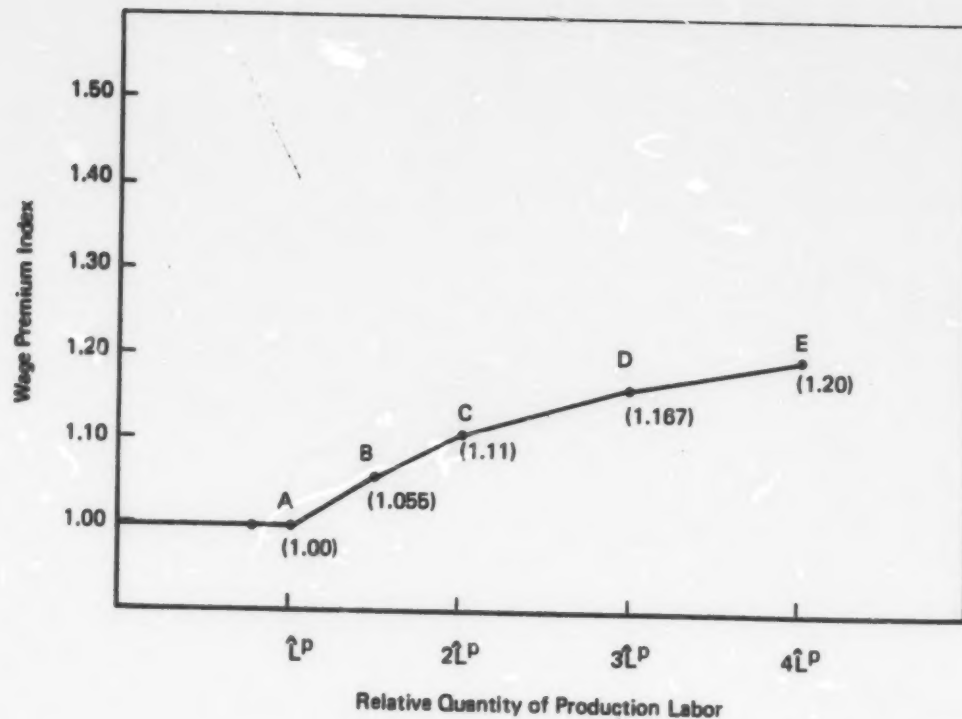
A-B:	4.3
B-C:	4.7
C-D:	4.4
D-E:	3.5

Notes:

$\hat{L}^s$ represents the current level of salaried labor utilization; $2\hat{L}^s$ represents the 200% level, etc.

The Salary Premium Index indicates the salary premium required to obtain additional labor.

FIGURE C-3 WATER POLLUTION CONTROL EQUIPMENT
a) Salaried Labor



Elasticities:

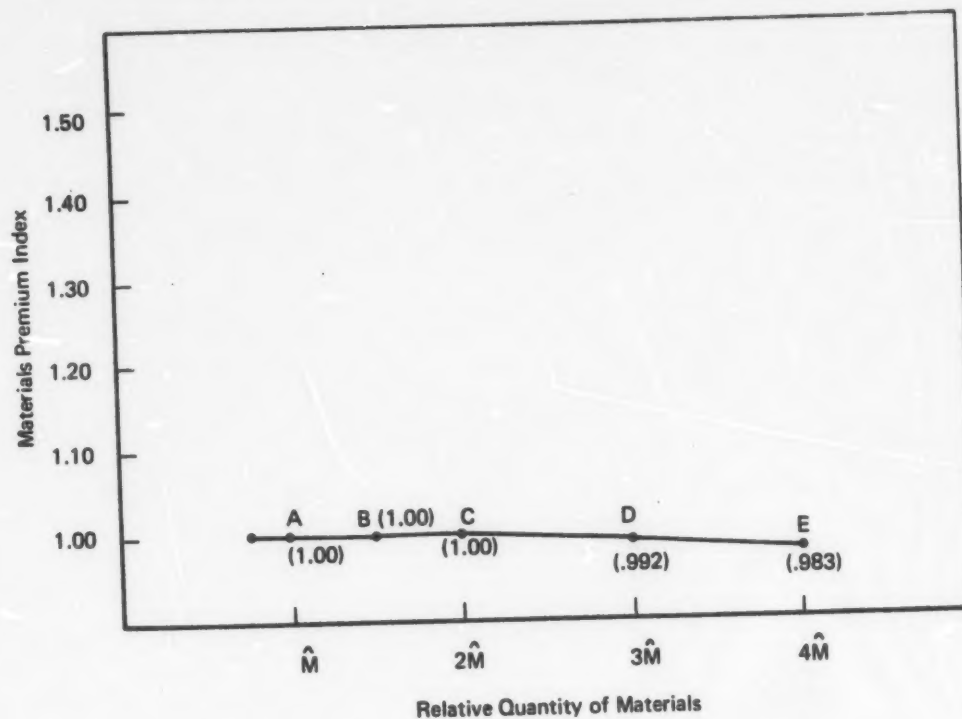
A-B:	9.1
B-C:	6.4
C-D:	9.7
D-E:	11.8

Notes:

$1\hat{L}^P$ represents current levels of production labor utilization; $2\hat{L}^P$ represents the 200% level, etc.

The Wage Premium Index indicates the unit wage premium required to obtain additional production labor.

FIGURE C-3 WATER POLLUTION CONTROL EQUIPMENT
b) Production Labor



Elasticities:

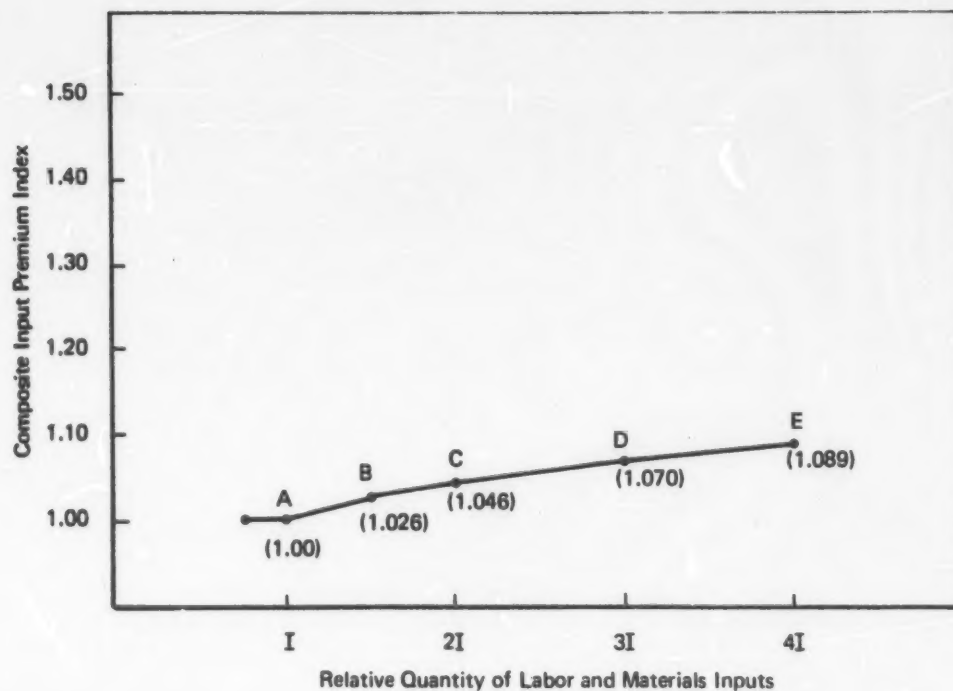
A-B: ∞
 B-C: ∞
 C-D: -62.5
 D-E: -37.0

Notes:

$\hat{M}$ represents current levels of materials utilization; $2\hat{M}$ represents the 200% level, etc.

The Materials Premium Index indicates the unit premium required to obtain additional materials.

FIGURE C-3 WATER POLLUTION CONTROL EQUIPMENT
 c) Materials



Elasticities:

A-B:	19.2
B-C:	16.9
C-D:	21.8
D-E:	18.5

Notes:

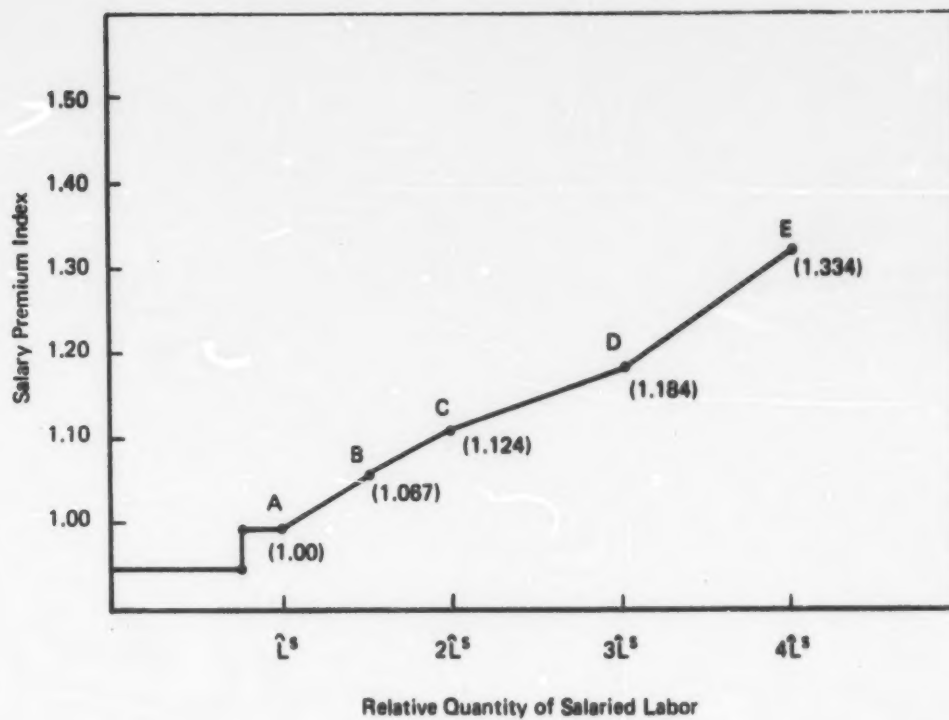
I represents current levels of input utilization; 2I represents the 200% level, etc.

The Composite Input Premium Index indicates the unit premium that must be paid to obtain increased amounts of inputs (labor and materials).

Relative weights from 1967 Census of Manufactures and industry sources:

Salaried Labor:	.16
Production Labor:	.14
Materials:	.70

FIGURE C-3 WATER POLLUTION CONTROL EQUIPMENT
d) Composite Supply Curve: Labor and Materials



Elasticities:

A-B:	7.4
B-C:	6.2
C-D:	9.4
D-E:	2.6

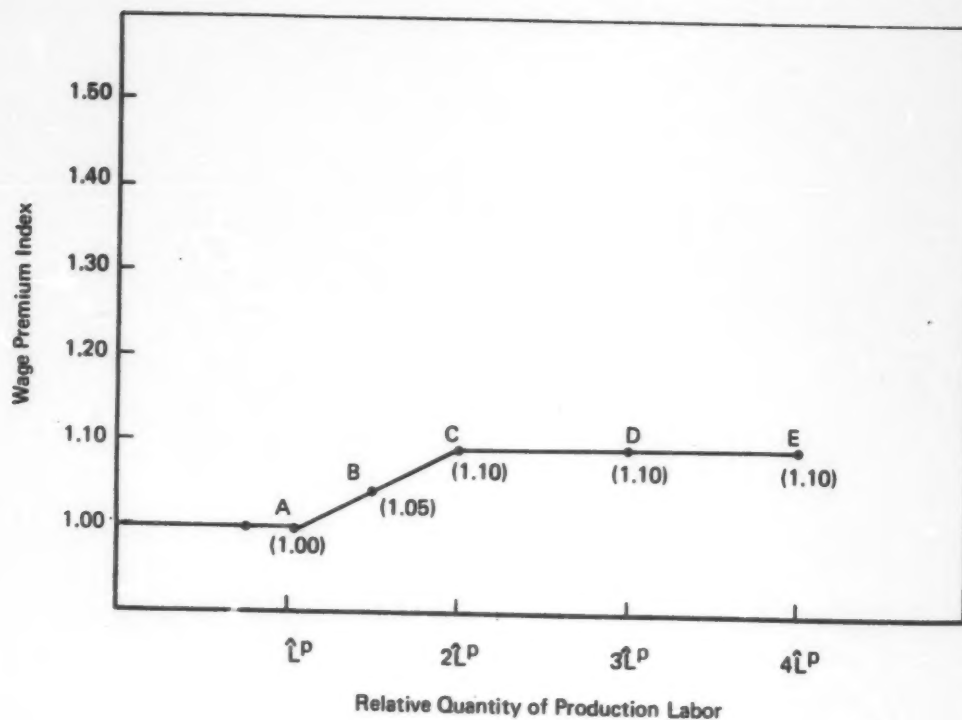
Notes:

$\hat{L}^s$ represents the current level of salaried labor utilization; $2\hat{L}^s$ represents the 200% level, etc.

The Salary Premium Index indicates the salary premium required to obtain additional labor.

*Limited information from our surveys required extrapolation at the 300% and 400% level.

FIGURE C-4 WATER SPECIALTY CHEMICALS
a) Salaried Labor*



Elasticities:

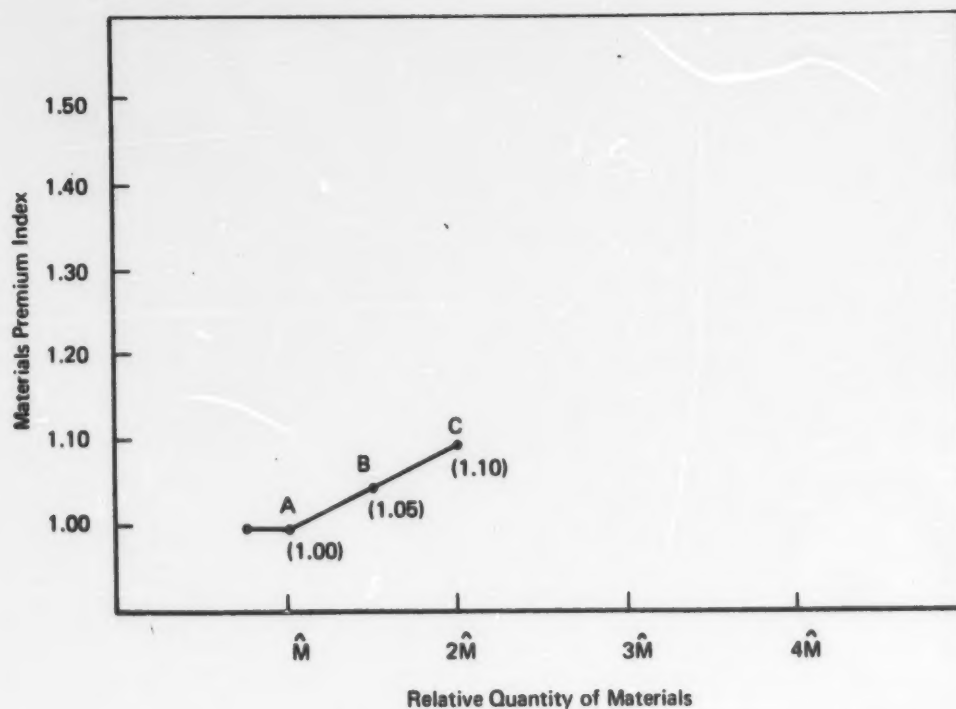
A-B: 10.0
 B-C: 7.0
 C-D: ∞
 D-E: ∞

Notes:

$\hat{L}^P$ represents current levels of production labor utilization; $2\hat{L}^P$ represents the 200% level, etc.

The Wage Premium Index indicates the unit wage premium required to obtain additional production labor.

FIGURE C-4 WATER SPECIALTY CHEMICALS
b) Production Labor



Elasticities:

A-B: 10.0

B-C: 7.0

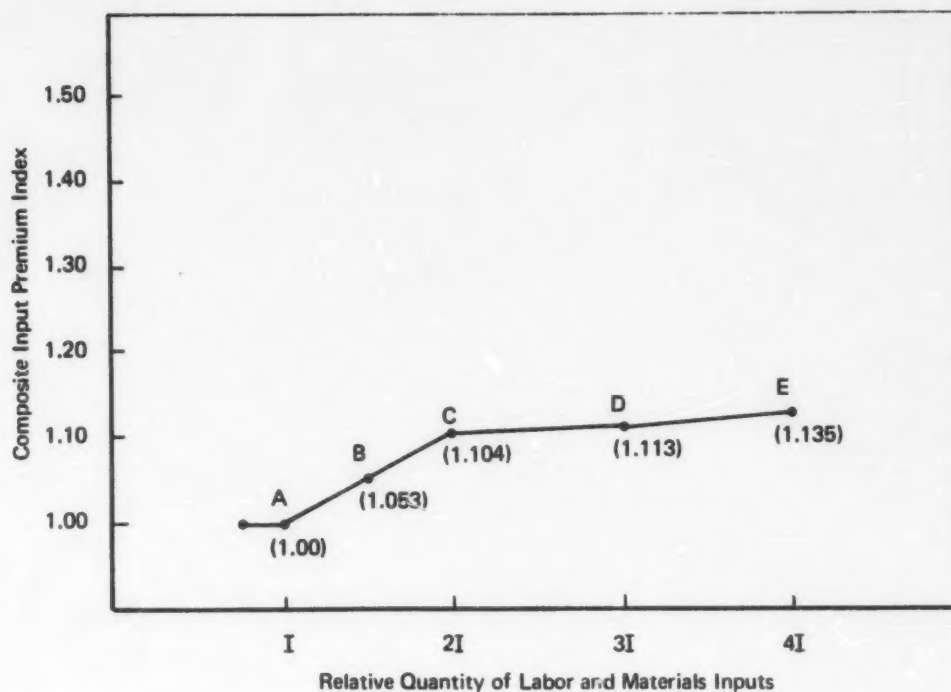
Notes:

$\hat{M}$ represents current levels of materials utilization; $2\hat{M}$ represents the 200% level, etc.

The Materials Premium Index indicates the unit premium required to obtain additional materials.

* Our limited survey information permits inference only $2\hat{M}$ (200%).

FIGURE C-4 WATER SPECIALTY CHEMICALS
c) Materials *



Elasticities:

A-B:	9.4
B-C:	6.8
C-D:	60.9
D-E:	16.8

Notes:

I represents current levels of input utilization; 2I represents the 200% level, etc.

The Composite Input Premium Index indicates the unit premium that must be paid to obtain increased amounts of inputs (labor and materials).

Relative weights from 1967 Census of Manufactures and industry sources:

Salaried Labor:	.15
Production Labor:	.10
Materials:	.75

* Materials curve extrapolated horizontally in 4-c to produce this composite curve.

FIGURE C-4 WATER SPECIALTY CHEMICALS
d) Composite Supply Curve: Labor and Materials*

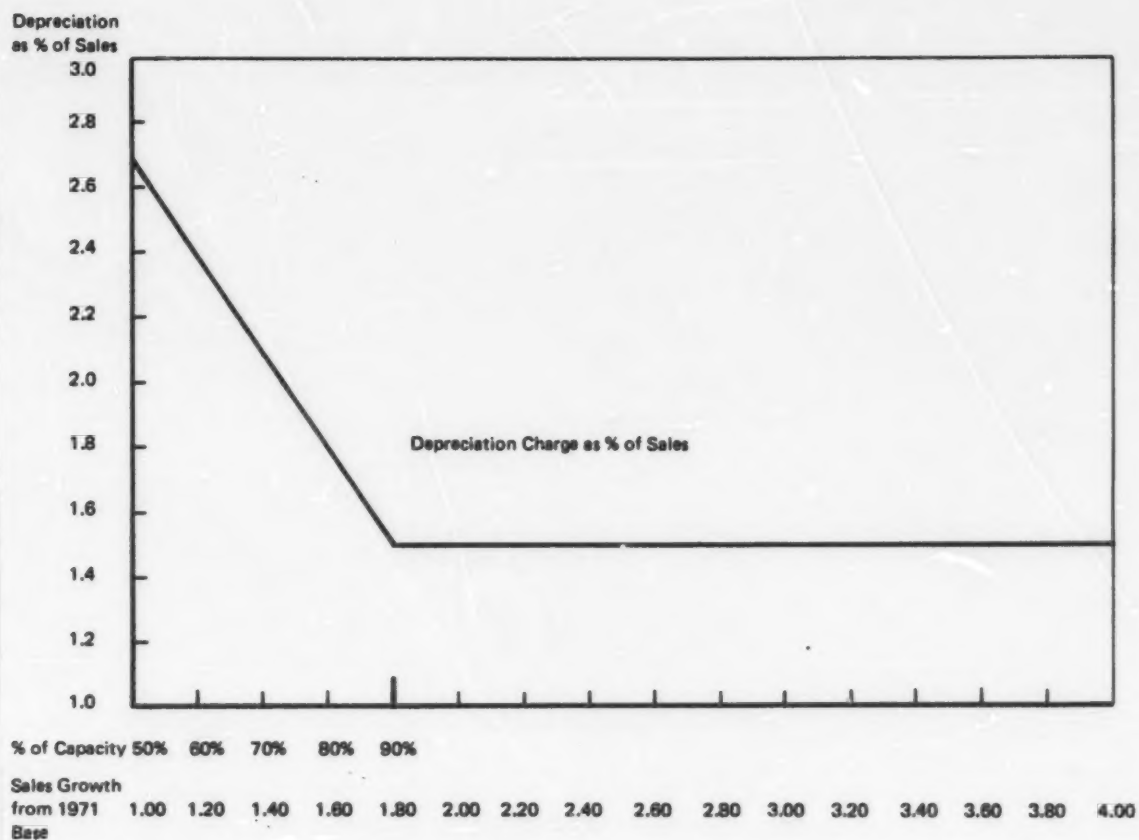


FIGURE C-5 PARTICULATE CONTROL EQUIPMENT
a) Supply Curve for Depreciation

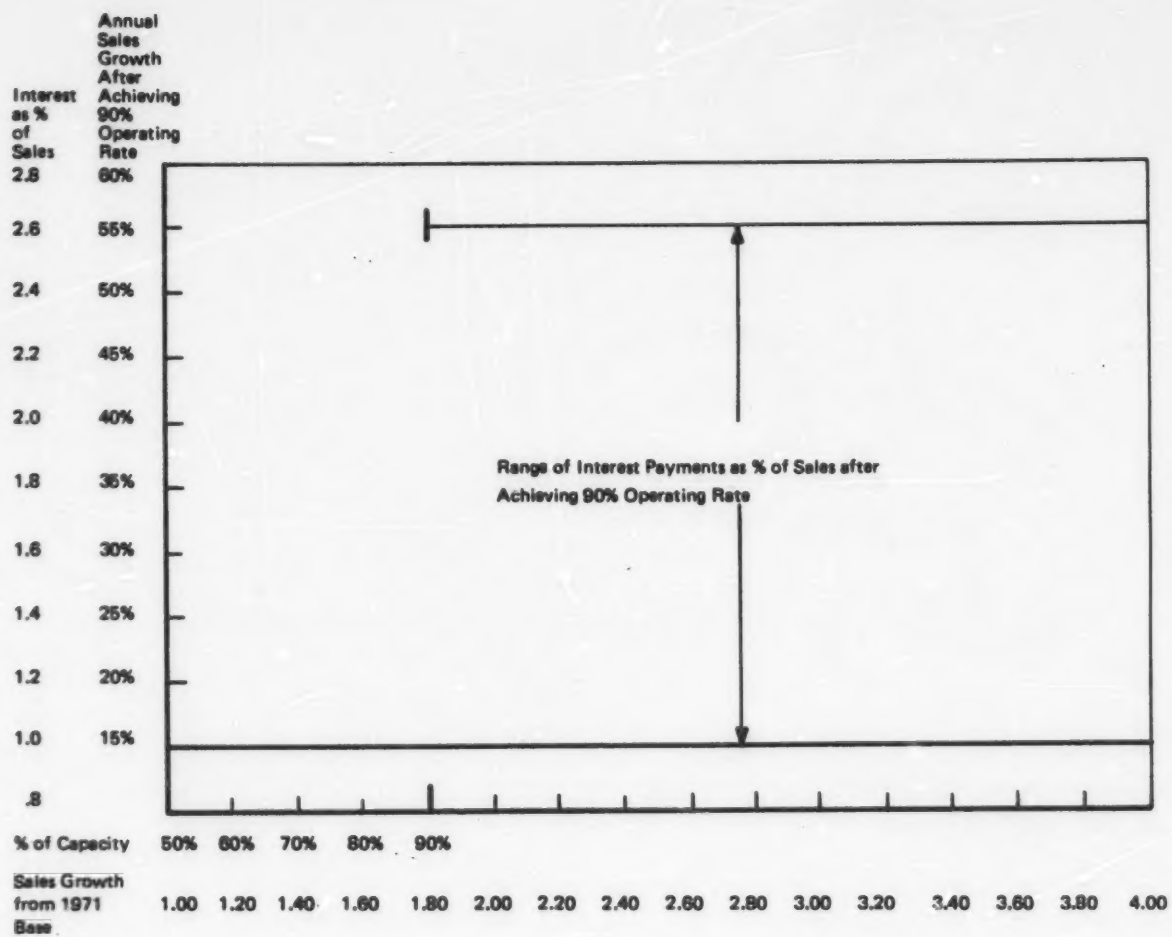


FIGURE C-5 PARTICULATE CONTROL EQUIPMENT
b) Supply Curve for Interest

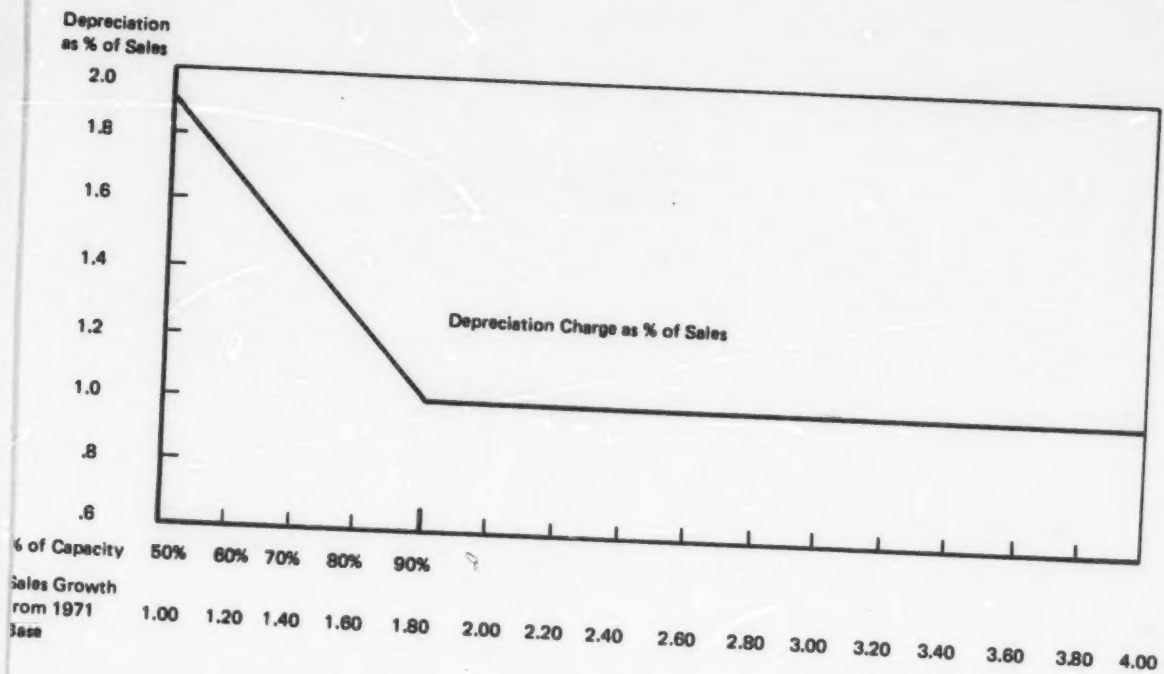


FIGURE C-6 GASEOUS CONTROL EQUIPMENT
a) Supply Curve for Depreciation

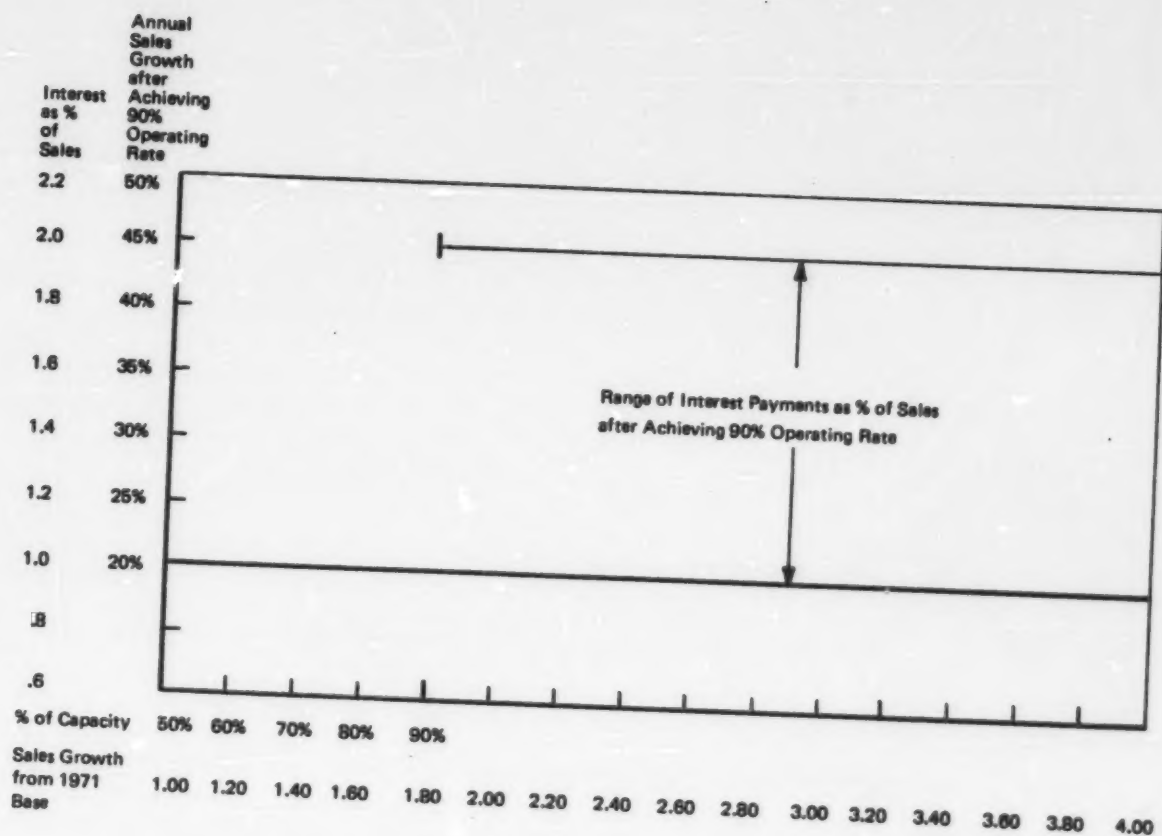


FIGURE C-8 GASEOUS CONTROL EQUIPMENT
b) Supply Curve for Interest

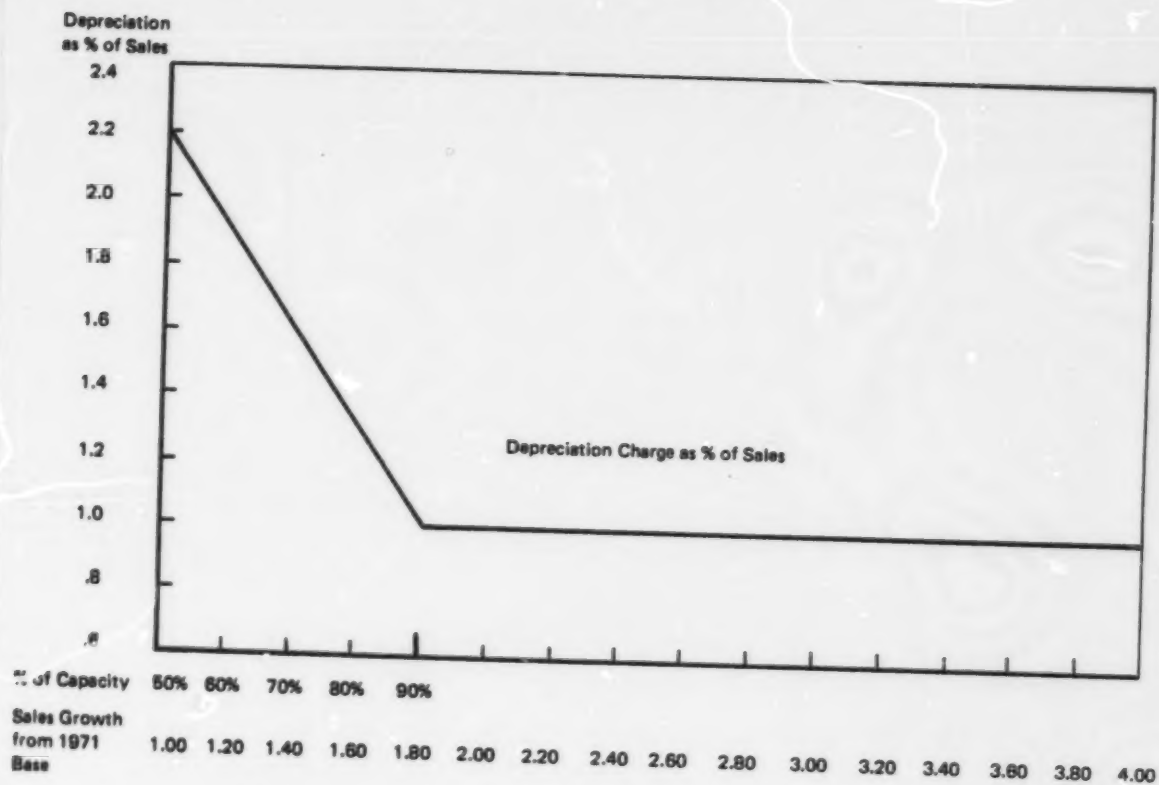


FIGURE C-7 WATER POLLUTION CONTROL EQUIPMENT
a) Supply Curve for Depreciation

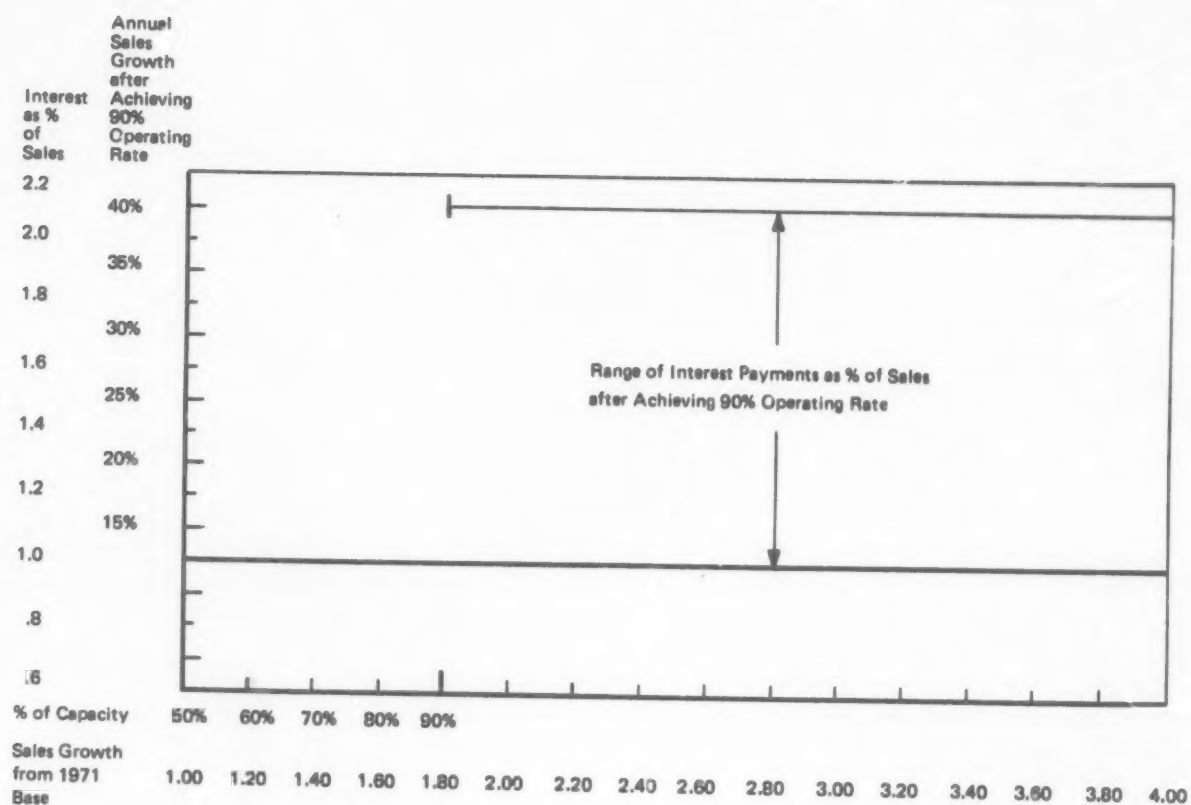


FIGURE C-7 WATER POLLUTION CONTROL EQUIPMENT
b) Supply Curve for Interest

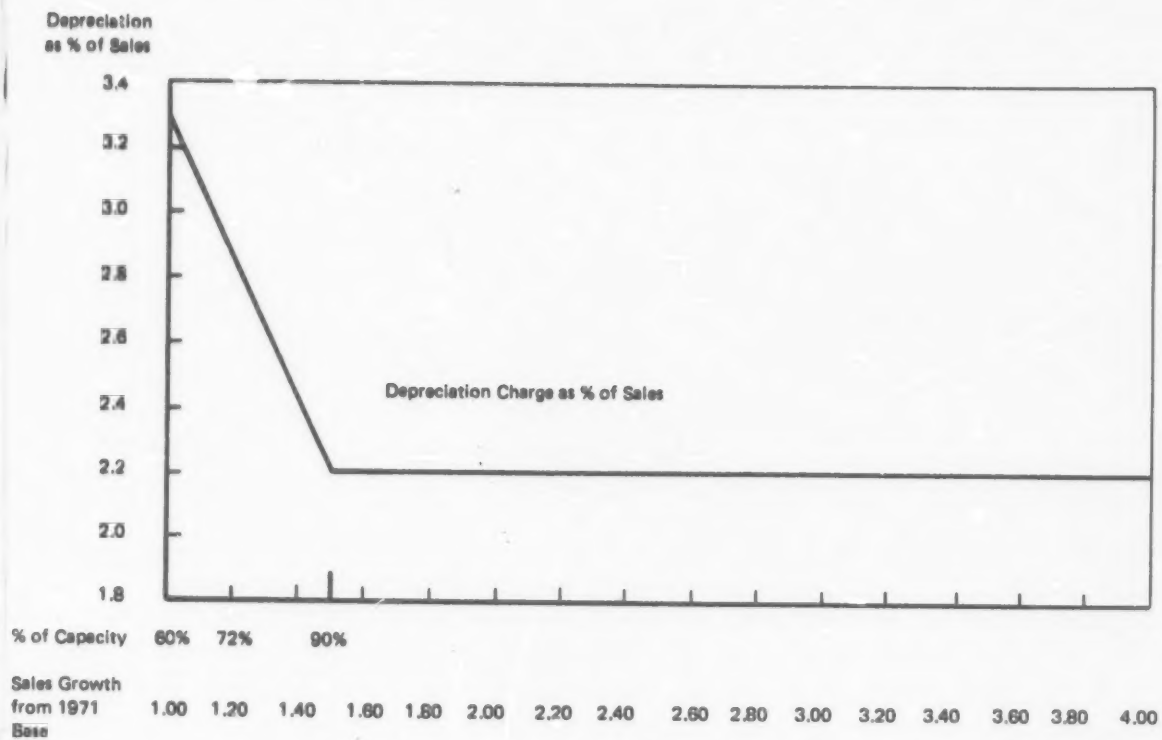


FIGURE C-8 INSTRUMENTATION
a) Supply Curve for Depreciation

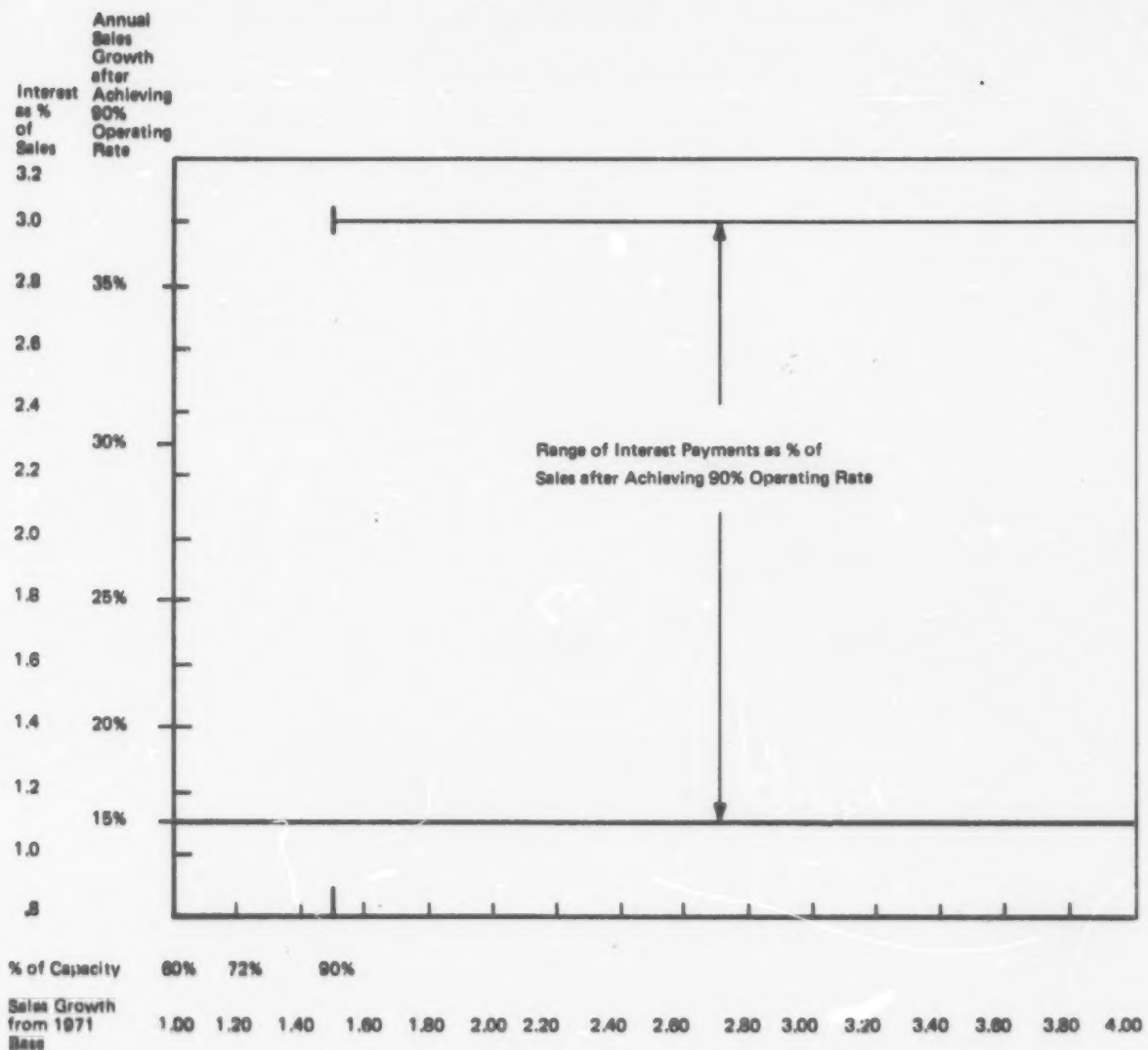


FIGURE C-8 INSTRUMENTATION
b) Supply Curve for Interest

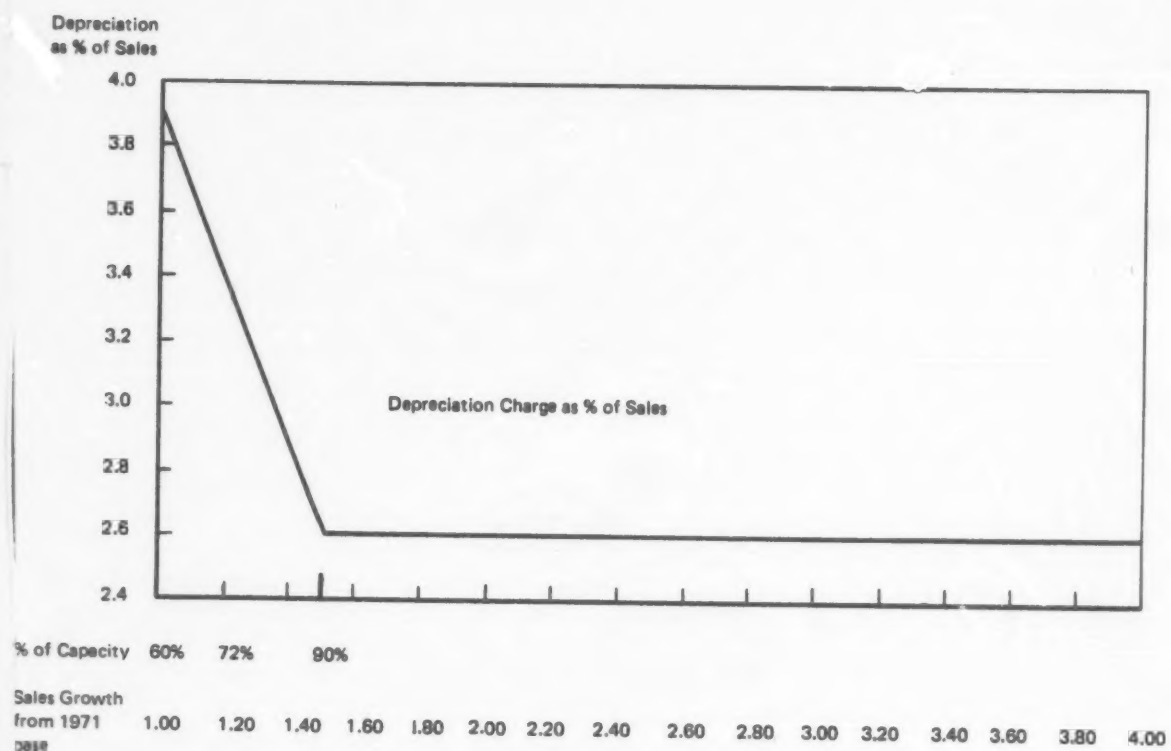


FIGURE C-9 SPECIALTY CHEMICALS
a) Supply Curve for Depreciation

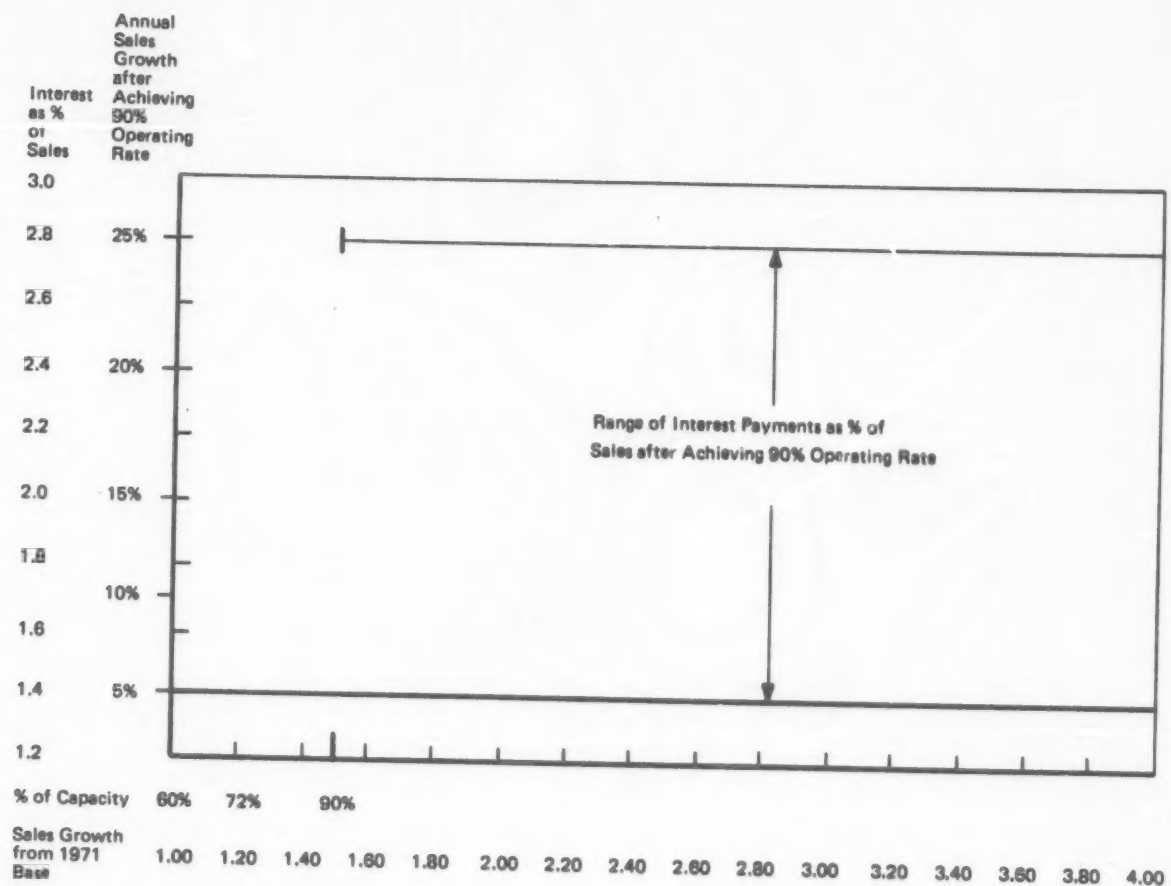


FIGURE C-9 SPECIALTY CHEMICALS
b) Supply Curve for Interest

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